Gas Journal

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Editorial Notes

The Research Meeting

THE keenest possible interest was displayed in the Reports and Papers presented last week at the Autumn Research Meeting of The Institution of Gas Engineers. This, of course, was to be anticipated, for the Communications are obviously of vital importance to the continued progress of our Industry. The change of policy of the Joint Research Committee of the Institution and Leeds University has been amply justified in the result. The Committee recognized that the Industry had equipped itself with chemists and physicists capable of studying and developing the processes now employed, and rightly turned attention to the exploration of newer processes. If, said Mr. E. V. Evans in his statement before relinquishing Chairmanship of the Committee, the Committee was called upon to frame terms of reference, they would be: "To develop yet more efficient methods for the scientific treatment of coal, to cheapen the cost of manufacture, and to explore the possibilities of the Gas Industry providing in the future much larger volumes of motor spirit and fuel oil." "This," he added, "is a very ambitious programme, and I fear the patience of the practical gas engineer may often be sorely tried."

We hope that this will not prove to be the case. The point of view of the "practical gas engineer" must change with the growing appreciation of the need for fundamental research, the findings of which cannot be sure of immediate industrial application. But the pure research of the Committee during the past year has opened up a most facinating vista in an unexpected way. Twelve months ago how many members of the Institution would have given much credence to the statement that something like two-thirds of a charge of semi-coke could be gasified in hydrogen yielding a gas containing over 30% of methane and possessing a calorific value of over 500 B.Th.U. per cu.ft.? This is a further example of the extraordinary flexibility of the gas-making process, and the discovery is of national importance as well as of the utmost significance to the Gas Industry. Concurrently with this investigation, work has been proceeding on the effect of changes in the composition of gas on its performance in appliances, and the outcome to date was reported at the meeting. It becomes increasingly apparent that the combustion characteristics of a gas should be made subject to measurement in such a form that the behaviour of the gas in appliances can be predicted with confidence. It is clear that the amount of work necessary to increase our knowledge of these matters is considerable. We regard both Reports of the Joint Committee as outstanding, and it was unfortunate that at the Research Meeting so little time was available for discussion and so many who had come prepared to speak were unable to join in the oral discussion. We acknowledge the improvement which has been made in the manner of presenting the various Communications; even now, however, it seems to us that the amount of time sometimes spent in their introduction is excessive.

At this stage we are only referring in general terms to the Research Meeting; we shall return subsequently to more detailed consideration of the Communications and their implications. But another outstanding Communication typifying the Industry's new conception of research and the value of team work is the Paper by Mr. Hollings, Mr. Hutchison, and Dr. Griffith. The work described in this contribution shows the possibility of producing gas containing practically no organic sulphur compounds; and it appears desirable that at an early date consideration should be given to the merits of the catalytic purification of gas as a preliminary to the oil washing process as well as a preliminary to the carbon process for the recovery of benzole. There is no doubt that if we can use gas in controlled quantities for space heating without any smell of sulphur, the possibilities of the future extension of the use of gas are enormous. During the meeting both Sir Harold Hartley, who was elected an Honorary Member of the Institution, and Mr. Evans spoke of the value of having independent units for the prosecution of research, with, of course, a proper measure of correlation. Mr. Evans, referring to the Report on sulphur removal from gas, said it provided a cause for gratification in that research work in the Gas Industry is not left in any one pair of hands or with one group of workers. "Is there not in all this," he suggested, "the answer to those who advocate the formation of an all embracing and all inclusive research institute which might enshrine and even embalm the best brains of the country?"

A dominant thought arising from this Autumn Re-

search Meeting is the need for a more definite lead in matters of technical policy. The value of research work such as that reported by Mr. Hollings and his collaborators will depend on the extent the findings are translated into practice. Too great an emphasis cannot be laid on this point.

The S.B.G.I. Meeting

THERE is reading matter enough in this issue of the "JOURNAL" for the most voracious student of Gas Industry affairs, and from our own, as well as our readers' point of view, we regret the custom which has grown in recent years of holding the meeting of the Society of British Gas Industries in the same week as the Autumn Research Meeting. However, the convenience to members of the Society, especially when there is also the B.G.F. meeting and dinner, is so obvious that Editor and reader clearly have no claims to press in the matter. At the same time it would be a thousand pities if sight were lost, in the general heavy outpourings at this season of the Gas Industry, of the excellent reviews which successive Chairmen of the S.B.G.I. have given us in recent years of the situation as they see it, from a viewpoint which by nature is more detached than many, and which is being somewhat tardily recognized as most important and valuable to the Industry.

So, in what might well be described as a Birmingham year, when Mr. A. W. Smith rules over the B.C.G.A., and Mr. Harold Smith (who freely acknowledges much of his success in the Industry to early days in Birmingham) is President of the Institution, we come to the Address which Mr. R. J. Rogers gave last week as Chairman of the S.B.G.I. From a masterly review under a great number of heads, what shall we select as the main theme? We believe Mr. Rogers, and indeed all his members, would have chief emphasis directed to Co-operation, which has been the basis of the Society's work, as exemplified by many of its Rules, since its formation more than 30 years ago. It is, however, only since the formation in 1934 of the British Gas Federation that full opportunity has been given to the contractors and manufacturers to exercise, in the counsels of the Industry, the influence of which they are capable to the benefit of all. Many examples of their active co-operation have been clear for all to see. A great many more, behind the scenes, have been genuinely appreciated by their colleagues on the other side of the Industry.

Great interest will be found in the chart which Mr. Rogers designed in illustration of his Address. It is indeed a comprehensive family tree of the Gas Industry, with the peculiarity that the Head of the Family was derived from the various branches—quite contrary to the usual workings of nature. It must surely be a very happy and united family which can meet together and agree upon the adoption of a common parent, and it is this kind of unity and agreement which is the best omen for the success of the Gas Industry in difficult days ahead. As far as concerns the S.B.G.I., the chart clearly indicates not only its many ramifications within the Industry, but its important contacts without.

Other subjects dealt with by Mr. Rogers included the proposed permanent Gas Industry Exhibit at the Science Museum. We have commented on previous occasions upon the exceptional position of the Gas Industry in being virtually unrepresented—alone among the great technical industries of the country—at South Kensington, and when the appeal of which Mr. Rogers speaks is launched in real earnest it will have every support that the "JOURNAL" can give. Here again is a cause which will almost certainly be successful now that there is such an organization as the B.G.F. to espouse it.

It is only natural that Mr. Rogers should have devoted a section of his Address to public lighting, and spoken stern words to the few in the Industry in whom a spirit of pessimism and apathy exists as regards the future of this important branch of our work. The wonderful part which members of the Society played in the recent A.P.L.E. Conference at Folkestone is universally acknowledged, and the results, we believe, were such as to remove pessimism from even the most hardened cases. Apathy is a stiffer proposition, but it simply must not be allowed to exist in any quarter, and the Industry is fortunate in possessing within the S.B.G.I. not only a number of outstanding technical experts, but a gas lighting section which is brimful of enthusiasm for its subject. It is an open secret that much of the "ginger" which has bred optimism in recent times in this direction has come from S.B.G.I quarters—further justification, if any be needed, of the existence of the B.G.F.

Many other matters of domestic, as well as general, interest in Mr. Rogers's Address must be passed over for the moment. We would, however, counsel a careful study of it as a review of the general policy of the Gas Industry by one specially qualified to make such review. Particularly would we make the point that thinking members among the "juniors" should on no account miss it.

Forthcoming Engagements

Nov.

13.—SCOTTISH WESTERN JUNIORS.—Meeting and Paper by D. S. Davies on "Gas as Applied to the Textile Industry."

13.—WESTERN JUNIORS.—Visit to Torquay. Paper on "Practical and Theoretical Aspects of Crude Benzole Recovery," by F. A. Butt.

17.—B.C.G.A.—Meeting of the Executive Committee, 11.30 a.m.

18.—I.G.E.—Gas-Works Safety Rules Committee, 2.30 p.m.

18.—MIDLAND ASSOCIATION.—Autumn General Meeting, Grand Hotel, Birmingham.

18.—MIDLAND JUNIORS.—Meeting and Paper by E. Haden on "Temperatures."

19.—SOUTHERN ASSOCIATION.—General Meeting, Hotel Victoria, 2.30 p.m. Paper by W. A. Bishop (Croydon) on "Developing the Heating Load with special reference to Gas-Fired Central Heating Installations." Committee meeting precedes at 12 noon.

19.—LONDON AND SOUTHERN JUNIORS.—Annual Dinner and Concert.

20.—YORKSHIRE JUNIORS.—Meeting at York.

23.—LONDON AND SOUTHERN JUNIORS.—Paper on "Heat Utilization in Carbonizing Plant" by J. H. Reber.

23.—I.G.E.—Pipes Committee, 2.30 p.m.

25.—I.G.E.—Purifiers Committee, 2.30 p.m. Gas-Works Safety Rules Committee, 3 p.m. [*The meeting of the latter Committee has been altered from Nov.* 18.]

26.—GAS COMPANIES' PROTECTION ASSOCIATION.—40th Annual General Meeting, Caxton Hall, Westminster, 2.30 p.m.; followed by Committee Meeting.

26.—NORTH OF ENGLAND AUXILIARY.—35th Half-Yearly Meeting at Newcastle-upon-Tyne.

27.—SCOTTISH WESTERN JUNIORS.—Visit to Auchengeich Coke Ovens.

30.—W.G.C.—Meeting of Training Committee, Gas Industry House, 10.30 a.m.

(There will be no meeting of the Central Executive Board of the National Gas Council or of the Central Committee of the Federation of Gas Employers during the month of November.)

OBITUARY

Ralph E. Gibson, M.Inst.C.E., M.Eng.

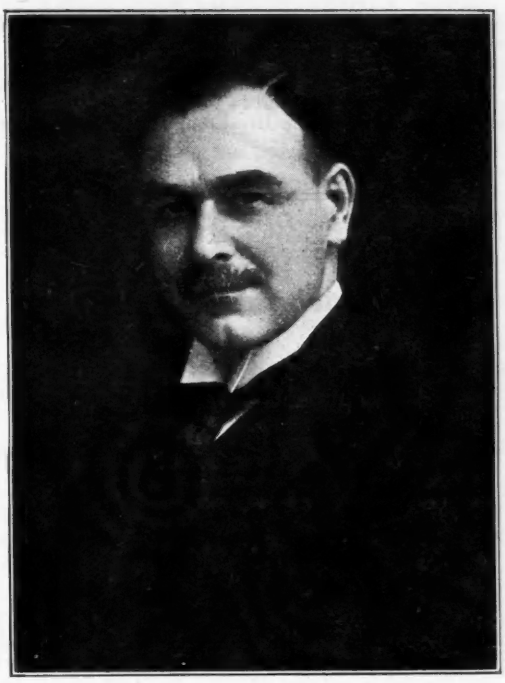
His many friends in the Gas Industry will be shocked to learn of the death of Mr. Ralph Ernest Gibson, Chief Engineer to the Liverpool Gas Company, which occurred with tragic suddenness last Sunday. He had a seizure while out walking near his home at West Kirby, and, although medical aid was summoned, he died almost immediately.

Mr. Gibson was educated at the Sheffield Royal Grammar School, and received his early training in the works and drawing office of Newton, Chambers, & Co., Ltd., where he served a pupil-apprenticeship of six years. He was afterwards engaged for a period of four years on that firm's staff in designing gas-works plant and other engineering structures, surveying sites, preparing plans, specifications, and estimates, and also in supervising erection. During this time he studied mechanical engineering and other subjects at the Sheffield Technical College. In 1899 he was appointed Engineering Assistant to the Huddersfield Gas Department, and for nearly five years was engaged there on renewals, extensions, and general supervision of the manufacturing plant and distributing system. From there he went, in 1904, to Liverpool—the largest company-owned gas undertaking in the provinces—in the capacity of Assistant Engineer, where for eleven years he was largely responsible, under the late Mr. Edward Allen (Chief Engineer), for the design and construction of extensive alterations and additions to the manufacturing plant, including a large amount of labour-saving machinery. On the death of Mr. Allen in 1915, Mr. Gibson was appointed Chief Engineer, being responsible for the administration of the Company on the technical side during the difficult period of the war. In later years many improvements were carried out by him—the carbonizing plant was modernized throughout, obsolete works at Caryl Street were closed down, new works constructed at Garston, the distribution system was improved and greatly extended, and two gas undertakings were absorbed—namely, Hightown and Woolton.

As is well known, Mr. Gibson contributed several valuable technical Papers to the Industry from time to time, the Liverpool Engineering Society, of which he was President in 1924, having awarded him its premium for a Paper entitled "The Mechanical Handling of Materials on Gas-Works," and The Institution of Gas Engineers the H. E. Jones London Medal for a Paper dealing with the "Construction of the New Gas-Works at Garston." He was elected a member of the Institution of Civil Engineers in 1919; became President of the Manchester District Association of Gas Engineers in 1923, and was elected to the highest office the Industry can offer—the Presidency of The Institution of Gas Engineers—in 1932. In March last he received an Honorary Degree at Liverpool University. His year as President of The Institution of Gas Engineers will be remembered for a most enjoyable meeting held in June, 1933, at Liverpool, when well-deserved tributes were paid to Mr. Gibson and the Undertaking which he controlled. The Chairman of the Company also referred to the debt of gratitude they owed to their Engineer—and all those who attended the meeting will recall with pleasure the unsparing efforts which were made by Mr. Gibson and his Company to make the members' stay in Liverpool a memorable one.

At the General Meeting in Liverpool, the Institution was given a Civic Welcome by the Lord Mayor and was received by Dr. G. C. Clayton (Chairman of the Liverpool Gas Company) the day before he received the honour of Knighthood.

In his Presidential Address Mr. Gibson took a broad survey of the Industry, stressing both the use of gas for



industrial purposes and the need for amalgamation of the smaller undertakings, a forecast of the developments which are receiving so much attention to-day. One of the most interesting of the social events was a tour of North Wales, including the special privilege of going through the Mersey Tunnel, then not fully completed. That day each member received an itinerary most carefully prepared by Mrs. Ralph Gibson and Mr. Allan Gibson.

Mr. Gibson's leadership and advice in the Industry, and particularly in the Lancashire District, will be greatly missed.

Mr. Gibson was 63 years of age and leaves a widow and three sons, to whom the Industry will join in extending their sincere sympathy in their sad loss.

PERSONAL

Presentation to Dr. Mellor

On the retirement of Dr. J. W. Mellor, F.R.S., from the post of Director of Research of the British Refractories Research Association, announced in last week's issue, the members decided to mark their appreciation of his valuable work for the ceramic industries in general, and the refractories branch in particular, by making him a presentation. Unfortunately, Dr. Mellor has not been well enough to attend any public function, and so the presentation was recently made at his home by the Chairman of the Association, Lieut.-Colonel C. W. Thomas, the Vice-Chairman, Mr. Frank West, and the Secretary, Mr. H. Halliday, who had been deputed to represent the subscribers.

Colonel Thomas handed to Dr. Mellor, on behalf of the subscribers, a cheque for £1,500. He recalled that when the Association was in rather low water during the slump conditions of a few years ago, Dr. Mellor had generously foregone his salary as Director of Research. The Council had not been unmindful of that action and now felt that such generosity should be repaid. They had, therefore, to ask Dr. Mellor to accept from the Association's funds the sum of £500, which they regarded in a certain sense as "conscience money." He added that the payment had the full approval of the Department of Scientific and Industrial Research. Mr. West and Mr. Halliday heartily joined with Colonel Thomas in all that he had said. Dr. Mellor thanked the donors in suitable terms.

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To mark his retirement after forty-three years' service with the Deal and Walmer Gas Company, announced in our last week's issue, Mr. H. W. Dunn, Accountant, was the recipient of gifts from the Officers and Staff of the

Company. His long and faithful service have already been recognized by the Chairman and Directors. Mr. J. F. Tyndall, Engineer and Manager, presided at the presentation.

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Mr. JAMES TENNENT, J.P., a Director of the Coatbridge Gas Company, has been elected Provost of Coatbridge.

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Mr. K. H. R. HAM, C.A., has been successful in gaining, out of some seventy applicants, the appointment of Accountant to the Worcester New Gas Light Company. Mr. Ham was educated at Watson's College, Edinburgh, and subsequently entered the accountancy profession, being articled to Messrs. Hunter, Smart, & Dickison, Chartered Accountants, Edinburgh. Upon the expiration of his Articles Mr. Ham was appointed to the Audit Staff of Messrs. Deloitte, Plender, Griffiths, & Co., Chartered Accountants, London. In June, 1931, Mr. Ham was admitted to membership of the Society of Accountants in Edinburgh, and shortly afterwards was appointed to the Accounts Department of the Brighton, Hove, and Worthing Gas Company, later becoming Rental Superintendent and finally, in 1936, Assistant Accountant.

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Not long ago there was established anonymously a £250,000 educational trust for Scotland, and now Edinburgh University is about to profit from benefactions which will provide for new residential halls, playing fields, lecture halls, and common rooms for men and women students. We learn that these benefactions are due to the generosity of Dr. J. D. POLLOCK, Chairman of the British Oxygen Company, who obtained a medical degree at the University of which he is such a good friend.

* * *

Mr. J. E. JENKINS, Registrar of Cardiff Gas Light and Coke Company, is shortly retiring after 46 years' service with the Company. Mr. R. J. Auckland, Secretary to the Company, recently presented a handsome grandfather clock in walnut case to Mr. Jenkins at a gathering of staff and officials. Reference to his popularity among his colleagues, and appreciation of his services, were made by Mr. H. D. Madden, Engineer and Manager; Mr. F. Boardman, Assistant Engineer; and Mr. B. J. Bell, District Superintendent.

News in Brief

CURRENT EVENTS IN THE GAS INDUSTRY

Interest in the Stand of the Leicester Gas Department was shown by H.R.H. Princess Helena Victoria during her visit to a recent Home Life Exhibition held in the City.

The Price of Gas at New Mills is to be increased by 4d. per 1,000 cu.ft. commencing from the December reading of the meters. The price of coke has already been increased by 2s. 6d. per ton.

Application is to be Made to the Board of Trade by the Ross Gas Company for a Special Order under the Gas Undertakings Acts, 1920 to 1934, among the provisions of which is a definition of the gas supply limits and authorization to erect and maintain gas-works plant on certain specified lands.

An Interim Statement by the Board of the British Oxygen Company, Ltd., discloses that results for the year to date are again a record. The interim dividend is maintained at the same level as in the past two years—7% or 1s. 4·8d. per £1 unit of stock, less tax. Last year's interim was followed by a scrip bonus of 6¾%, and the final dividend of 8% was paid on the increased Ordinary capital of £2,841,252.

"Christmas Fare" is a timely addition to the B.C.G.A. series, "A Thousand and One Uses for Gas." With its gay cover, this publication must make a ready appeal even to the housewife of fairly long standing, for even she, as Helen Burke points out in an introduction, has had comparatively little experience of cooking a Christmas dinner. After all, Christmas comes but once a year, and between each Christmas dinner there is a twelve months' interval in which one can easily forget.

A Change of Name to the North Cheshire and District Gas Company is the first provision of a Special Order for which the Hyde Gas Company intend to apply to the Board of Trade in pursuance of the Gas Undertakings Acts, 1920 to 1934. Among other provisions is one which seeks authorization to transfer to and vest in the Company the gas undertakings of the Dukinfield and Denton Urban District Councils, together with the necessary extensions of the Company's limits of supply to embrace such added areas.

A Special Joint Meeting of the Illuminating Engineering Society with the Industrial Lighting Section of the Society and the Association of Supervising Electrical Engineers will be held by kind invitation of the E.L.M.A. at the Lighting Service Bureau, 2, Savoy Hill, W.C. 2, at 6.30 for 7 p.m. on Nov. 16, when a Paper entitled "Lighting for Special Industrial Processes" will be presented by Mr. S. Anderson and Mr. W. R. Stevens. Members of The Institution of Gas Engineers will be welcome. Invitation cards and copies of the Paper may be obtained on application to the Hon. Secretary (Mr. J. S. Dow, 32, Victoria Street, S.W. 1).

Among Attractions at the Ideal Home Exhibition, held in the Waverley Market all last week, was that set up by the Edinburgh Gas Department, in the form of a cinema hall, the largest building ever erected in the Waverley Market, Edinburgh, where shows were given at regular intervals. There were also demonstrations of the preparation of simple baked dishes. The Department had, in co-operation with manufacturers, arranged at their large exhibit a comprehensive display of cooking, heating, and lighting appliances, and each day very large crowds visited this interesting feature of the exhibition.

The Chemical Engineering Group of the Society of Chemical Industry are holding a Conference on Jointing and Packing which will be held in the Chemistry Theatre, Room 11b, King's College, Strand, W.C. 2, on Thursday and Friday, Nov. 18 and 19. Members of The Institution of Gas Engineers are invited to attend the Conference, on the Thursday of which the following Papers of interest to the Gas Industry are being read: "Some Bonding Materials containing Silica and Silicates," by Dr. H. W. Webb (Principal, North Staffordshire Technical College), and "Some Lutes and Cements Used in the Heavy Chemical Industry," by Mr. H. D. Greenwood and Mr. F. C. Snelling (South Metropolitan Gas Company), between 2.30 and 4.30 p.m.

A Cookery Competition organized by the Guernsey Gas Light Company in connection with the Cookery Section at the recent Guernsey Eisteddfod attracted seventy entrants. Prizes consisted of a "New World" cooker, gas iron, "Raybol" heater, and a gas poker. The articles to be cooked were chosen by Miss Sanderson, of the Radiation Research Kitchen, and the judging was done by two ladies from the Good Housekeeping Institute, all the entries being judged to be of a very high standard. The competition of the State's Electricity Department contrasted sadly with that of the Gas Company, the number of entrants totalling three, only one returning an exhibit, which was awarded second prize with the comment "not sufficiently cooked."

At the Official Opening by the Mayor of Cambridge of the Coleridge Senior School a corner of the Science Room was occupied by a compact display representing the Gas Industry, for which the Cambridge University and Town Gas Light Company was responsible. A supply of the pamphlet, "The Romance of a Lump of Coal" was available, and, in addition to a display of by-products, meters were on view with the front removed to show the working parts. The applications of gas were demonstrated by a refrigerator, a modern cooker, and fire. A spectacular finale was provided by Mr. Therm, who appeared as an attachment to an "Electrolux" refrigerator unit, with the result that while his body was coated with white frost, gas burners provided a flaming headpiece.

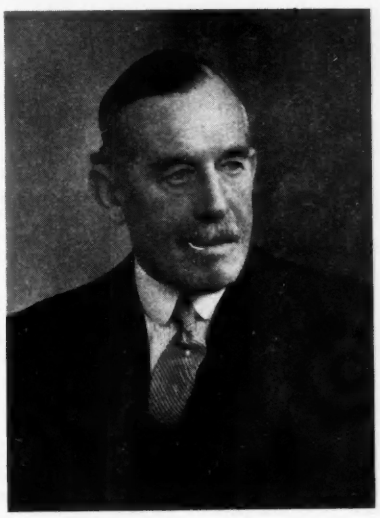
A Presentation

To
Sir David
Milne-Watson, Bart.,
LL.D., D.L.
Chairman of the Council of the British Gas Federation;
President of the National Gas Council of Great Britain and Ireland;
Vice-President of the British Commercial Gas Association;
Vice-President of the Society of British Gas Industries;
Chairman of the Federation of Gas Employers;
Chairman of the National Joint Council for the Gas Industry;
Vice-President of the Conjoint Conference of Public Utility Associations;
Chairman of the British Sulphate of Ammonia Federation Ltd;
President of the National Benzole Association;
President of the British Road Tar Association;
Vice-President of the Women's Gas Council.

Recognition of Many Services to the Gas Industry

ALL who were present last Wednesday at the Third Annual Dinner of the British Gas Federation must have counted themselves fortunate in participating in a function which was memorable in more than one respect. A record assembly testified to the ever-increasing vigour of one of our greatest national industries, and there was obviously abroad that spirit of restrained optimism which "gets things done." Vital considerations indeed, from the corporate point of view, and considerations which provided an admirable setting for what was undoubtedly the event of the evening.

The Gas Industry owes more than it can ever repay to Sir David Milne-Watson, and, knowing him, we know that he is content to have it so. But this year the twenty-first anniversary of the formation of the National Gas Council provided an opportunity of marking in a tangible manner appreciation of his unequalled services and the affection and esteem in which he is held. The presentation of this mark of appreciation, affection, and esteem it is which will make the third annual dinner of the British Gas Federation a lasting and most happy memory from the personal point of view. Forty years is a long service to an industry. Yet many of us have known Sir David for practically the whole of that time, and throughout the years have found in him the unswerving loyalty which is the hall-mark of the true friend, and the strength of character and the straightforwardness which are the main attributes of the true leader.



It was a gratifying thought, too, that the actual presentation of these tokens of affection and esteem was in the capable hands of the Earl of Dudley, as President of the British Gas Federation. Simply and briefly, he went right to the heart of the matter, when he said to "the Grand Young Man of the Gas Industry": "These gifts are but a token; they do not represent the enormous wealth of love which we have for you in our hearts." The loyalty and co-operation to be found in the Gas Industry to-day, he rightly ascribed to such leaders as Sir David Milne-Watson; and, in his speech of thanks, Sir David, in the same connection, took us back for a few moments to the past, when he referred to some of the leaders of the Industry whom he had been privileged to know in his younger days, but who were no longer with us—among others, Sir Corbet Woodall, Sir George Livesey, Mr. Harry Jones, and Sir Arthur Duckham. All, like Sir David himself, doughty fighters in a great cause.

The gifts, which were exhibited in the banquetting hall, comprised a portrait in oils of Sir David, by Harold Knight, R.A., a beautiful selection of silver plate, and a choicely illuminated album containing the names of all the subscribers. For Lady Milne-Watson, who, as the President declared, had done so much to help Sir David in his work, there was a lovely diamond bracelet, and loud was the applause when the Earl of Dudley gracefully placed it upon her wrist.

Widespread Activities.

Among our illustrations is the page from the illuminated album which indicates Sir David's main activities on behalf of the Industry to which he has so whole-heartedly devoted his life's work. This shows him to be Chairman of the Council of the British Gas Federation, President of the National Gas Council of Great Britain and Ireland, Vice-President of the British Commercial Gas Association, Vice-President of the Society of British Gas Industries, Chairman of the Federation of Gas Employers, Chairman of the National Joint Industrial Council for the Gas Industry, Vice-President of the Conjoint Conference of Public Utility Associations, Chairman of the British Sulphate of Ammonia Association, Ltd., President of the National Benzole Association, President of the British Road Tar Association, and Vice-President of the Women's Gas Council.

The lay-out of the constitution of the National Gas Council sprang from the brain of Sir David, as can be seen from the original draft among the records at Gas Industry House. He was the mainspring of the British Gas Federation, and of the Women's Gas Council (for whom he induced Lady Londonderry to fill the office of first President); while he also had much to do with the genesis of the Conjoint Conference of Public Utility Associations.

In other directions, Sir David was the founder of the British Sulphate of Ammonia Federation, and has been Chairman since its inception in 1920. Thus for seventeen years his guiding hand has controlled the Federation, which now represents about 90% of the sulphate of ammonia manufactured in this country. In 1919 he founded the National Benzole Association, to further the interests of benzole producers in Great Britain, and has acted as President since its inception. The activities of the Association since its formation have increased nationally and internationally with the general development of the benzole industry both at home and abroad. Sir David was

primarily responsible for the formation in 1927 of the British Road Tar Association. He has been President since that date, and has all along taken an active interest in the affairs of the Association.

The Industry's Appreciation.

The main part of the preamble to the presentation volume is in the following terms:

> To SIR DAVID MILNE-WATSON, Bart., LL.D., D.L.
>
> Your Colleagues and Associates in the Gas Industry welcome the opportunity presented by the 21st Anniversary of the formation of the National Gas Council of expressing their appreciation of the many and inestimable services which you have rendered to the Industry and of asking your acceptance of tangible tokens of their gratitude.
>
> Although as Governor of the largest Gas Undertaking in the world your responsibilities are exceedingly heavy, you have not hesitated to give liberally of your time, knowledge, and experience to the building-up and consolidation of the various National Organizations representative of the different Sections of the Industry. By so doing you have enabled the Industry to be welded into a comprehensive and powerful Federation.
>
> We recall with especial gratitude your work on the National Joint Industrial Council. By your wise and sympathetic handling of the many problems with which that body has from time to time been confronted, you have not only been instrumental in maintaining peaceful and happy relations between employers and employees, but have succeeded in creating an atmosphere of mutual trust and understanding throughout the Industry.
>
> As Governor of The Gas Light and Coke Company, you have enlisted on our behalf the support of that great Undertaking, and we record with satisfaction the latest manifestation of its goodwill which has enabled the National Organizations to be worthily and conveniently established in Gas Industry House, occupying one of the finest sites in London.
>
> The gifts which accompany this address are a portrait of yourself, which—with your consent—will be placed in Gas Industry House, than which there can be no more appropriate setting; a collection of silver; and, as a mark of special appreciation of Lady Milne-Watson's ready assistance in all your work, some jewellery for her personal use.
>
> This volume contains the names of those who have had the pleasure of being associated with this Presentation.

With regard to the arrangements for the presentation, it may be recalled that a Sub-Committee was appointed by the Central Executive Board of the National Gas Council (consisting of Mr. William Cash, Vice-Chairman of the Board, Alderman J. E. Daw, Mr. A. W. Smith, and Mr. T. P. Ridley), with instructions to appeal to the Gas Industry for funds for the purpose. Although Mr. Cash presided at the first meeting of the Committee, he was unfortunately prevented by illness from attending on every occasion, but he was kept fully informed as to the proposals and suggestions that were being made. In these circumstances, Alderman Daw acted as Chairman, and kindly consented to be Treasurer to the fund. The Sub-Committee held a large number of meetings, and the members are to be complimented upon the outcome of their labours; an outcome which affords such eloquent testimony to the great value of Sir David's services to the Gas Industry in all its branches and to the personal esteem in which he is held.

A Leader of Men.

It is recognized that Sir David possesses exceptional qualities as a leader of men, and it is well known that other industries covet such a leader. Although when the occasion demands Sir David can be firm and unbending, yet when the cause is eradicated it is impossible to remember anything but his charm. Without a leader of this calibre, it is no exaggeration to say that the position of the Gas Industry would have been very different from what it is to-day. When Sir David is satisfied that his cause is just, he knows no fear and shows no favour, and it is characteristic of his speeches in public that he invariably makes a statement which gives a certain section "furiously to think."

A book might well be written on Sir David's work in connection with the application of the Whitley Scheme to the Gas Industry in the year 1919, and the whole history of that Council is largely bound up with the successful relationship between Sir David and the administrators of gas undertakings throughout the country on the one hand, and the Trade Union leaders on the other. It must be admitted that we have been fortunate in the Gas Industry in the character of the leaders of the Trade Unions with which we have had to deal, but it has been clear all along that the Trade Union representatives recognized that in Sir David they were dealing with a man in whom they could place implicit trust, and who had himself visualized ideals for his own workers, and for the workers in the Industry throughout the country. It is not mere lip-service which gives him a prominent place among the industrial leaders of the century.

As is well known, great benefit has accrued to the workers as the result of the operations of the National Joint Industrial Council for the Gas Industry, and this has been accomplished by facing facts and probing down to the essential truths of the position. One of Sir David's outstanding 'characteristics is that he can be approached by all, and is ever ready to welcome suggestions containing elements of good for the Industry.

A United Industry.

While it is true that, before Sir David was appointed Chairman of the Central Executive Board of the National Gas Council, the British Commercial Gas Association had included in its ranks municipal gas undertakings, it was the establishment of the National Gas Council which enabled municipal authorities to join with representatives of gas companies and take their full share in the work and management of the Gas Industry; and the membership of the Council now embraces all important municipal gas undertakings throughout the country.

This is a development which has proved beneficial to all alike. Representatives of gas companies have learned much from the working of municipal undertakings, and there is no doubt, also, that municipal undertakings have derived real benefit from experience gained of administration by companies. With the two sections working as one for the general good, it would be difficult to imagine a more united industry than ours.

Throughout Sir David's career he has always expressed appreciation of those who served him loyally in the Industry. If one may venture to say so, the impression which he has given when honours have been conferred upon him has been that he was receiving them on behalf of the Gas Industry. Nor have these honours caused him to stand aloof or withdraw from his work.

May he long be spared to continue to guide the destinies of our great Public Utility!

Some Biographical Notes.

Sir David Milne-Watson began his education at Merchiston Castle School, Edinburgh. After taking his degree at Edinburgh University, he obtained practical legal experience in the office of a well-known firm of Writers to the Signet, and then went to Balliol College, Oxford, and on to Marburg. He contested S.E. Essex in 1895. In 1896 he was called to the English Bar, and shortly afterwards married Olga Cicely, daughter of the late Rev. George Herbert. He has three children. Sir David has an estate in Dorset, and takes much interest in farming and gardening, as well as in shooting. He is also a keen fisherman. He finds great pleasure in foreign travel, and has visited most countries in Europe, also Egypt and the United States. In 1897 he entered the Gas Light and Coke Company, becoming General Manager in 1903, Managing Director in 1916, and Governor of the Company in 1918.

Sir David has always been a keen supporter of ordered progress and unity, and is an enthusiastic and staunch advocate of the co-partnership principle, which has been so largely responsible for the industrial peace and good fellowship between employers and employed that is characteristic of the Gas Industry. Co-partnership was inaugurated in the Gas Light and Coke Company in 1909, and Sir David takes a keen interest in all the schemes promoted for the welfare of the co-partners. He is a member of the County of London Territorial Army and Air Force Association, and is Hon. Colonel of the "Rangers," the King's Royal Rifle Corps, which is largely recruited from the Company.

In addition to his great work in connection with the national bodies of the Gas Industry, Sir David is Chairman of the Government Committee dealing with Market Supply, and he has served on the Committee on Problems of Rationalization, the National Fuel and Power Committee, the Gas Legislation Committee, the Advisory Committee of the Board of Trade and the Department of Scientific and Industrial Research, and on the Industrial Court. He is a Past-President of the National Confederation of Employers' Organizations, and has represented the employers at International Labour Office Conferences at Geneva. Further, he is a member of the Joint Committee to explore "the entire field of industrial re-organization and industrial relations," was President in 1927 of the Association for Education in Industry and Commerce, and of the International Congress on Commercial Education in 1932, and also served on the "Malcolm" Committee on Education and Industry.

Sir David is greatly interested in the question of education. In the Gas Light and Coke Company every en-

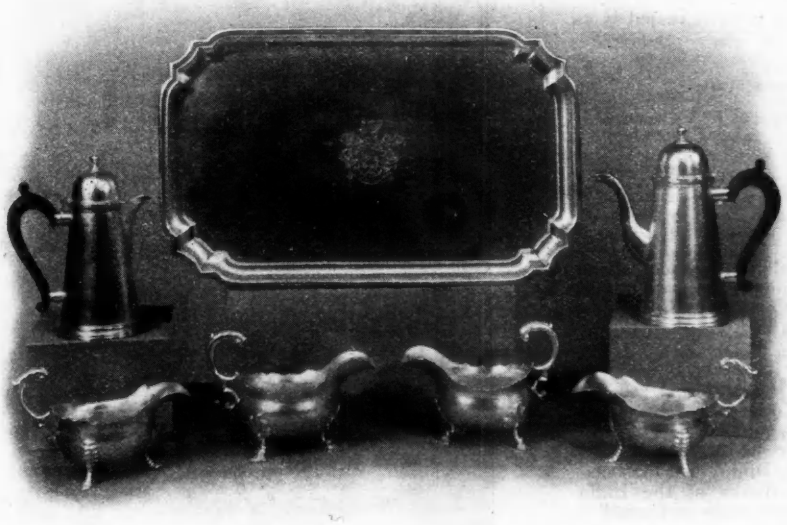
couragement is given to employees to follow courses of instruction germane to their particular side of the Company's activities, by granting them special facilities for study and by payment of their class fees, &c. There are also various pupilship and apprenticeship schemes, many of which owe their origin directly to his encouragement.

During the war he was a member of the Ministry of Food Committee on Distribution of Sulphate of Ammonia and the Ministry of Munitions Departmental Committee on the position of Fertilizer Trades. He was also Chairman of the Hospital Supplies Committee which supplied and equipped two of the largest General Hospitals in London.

The Presentation

In making the presentation the Rt. Hon. the EARL OF DUDLEY said: "It is my very honourable and pleasant duty to make a presentation to the "Grand Young Man of the Gas Industry," who has been our presiding genius for so many years, and to Lady Milne-Watson, on behalf of their many admirers in the Gas Industry who hold them in such a very great and deep and affectionate esteem. Sir David, I have no doubt it is a great honour to you to accept these gifts from your many friends in the Industry, but I can assure you that it is not nearly so great an honour as it is to me to have the pleasing duty of presenting them to you. I have no doubt that these gifts will give you and Lady Milne-Watson great pleasure in receiving them, but that pleasure is not nearly so great as is the pleasure of your many friends in giving them to you. I have no doubt that goodwill of the 120,000 people employed in the Gas Industry. Thereafter, turning to Lady Milne-Watson, he said he hoped he was setting a very good example to Sir David when he placed this diamond bracelet on her wrist. He hoped it would not be the last which would find its way there.

Sir DAVID MILNE-WATSON, who was given a most cordial reception, said: "I am sure you will understand my feelings to-night when I stand before you as the recipient of these wonderful gifts which you have just bestowed upon me and my wife. You have presented me with a most beautiful book which contains the names of all of you who have so kindly subscribed to this testimonial to-night. You have presented me with a portrait which has been painted by that very distinguished artist, Mr. Harold Knight, R.A., and it is for you to judge whether it is



Description of Silver Plate.

A pair of George II. Silver Sauceboats made in London in 1749 by Wm. Shaw and Wm. Priest.

A pair of George II. Silver Sauceboats made in London in 1750 by John Rowe.

A Silver Coffee Tray
A Silver Coffee Pot
A Silver Hot Milk Jug
} Reproductions of originals made in the reign of George I.

(Supplied by Crichton Bros., 22, Old Bond Street London, W.)

Inscription on Tray

Presented to
Sir DAVID MILNE-WATSON, Bart., LL.D., D.L.,
by his friends and colleagues in recognition of the many and inestimable services rendered to the Gas Industry.

3rd Nov. 1937.

in after years when you look at these gifts they will conjure up in your minds affectionate and sentimental memories of all those with whom you have been closely associated for so many years; but again I can assure you that these feelings will not be nearly so strong as the feelings of affectionate sentiment that are in our hearts this evening when we give them to you. These gifts are merely a token; they do not represent the enormous wealth of love which we have for you in our hearts, and I hope that the Illuminated Address which I have to read to you presently expresses properly and suitably those feelings. I hope that this picture which I have to unveil represents you as we see you. It has been painted by a very distinguished artist. At all events, you may take it that your image and that of Lady Milne-Watson, who has done so much to help you, we all know, in your great work, will live for ever in our memories. I do not want to say more at this moment. It is one of those occasions when words are extremely difficult and when feelings, perhaps, strike a more affectionate chord than words. I ask you to accept these gifts on behalf of the Gas Industry."

The PRESIDENT then unveiled a portrait in oils of Sir David Milne-Watson and at the same time presented him and Lady Milne-Watson with a collection of silver, suitably inscribed, and with an Illuminated Address. The President added that this Address was accompanied by the like me or not. You know there are always three men: the man you think you are, the man other people think you are, and the real man. Is that portrait the man I think I am? Is it the man you think I am? I do not know. It may be the real man or not, but at any rate that will be judged some day. However, I do appreciate the great honour you have done me and my wife in presenting us with these gifts. I appreciate them enormously—not only for their intrinsic value, but far more for the sentiment which has prompted them.

"I have been with you now in the Gas Industry as a brother worker, shall I say, for just over forty years; it is a curious coincidence that this is my fortieth year in the service of the Industry. Little did I think when I was born in Edinburgh and lived in Edinburgh and was trained for the Scottish Bar along with my friend Lord Macmillan, and left it for the English Bar—to his great relief—that my lot would be in another form of gas, if I may say so—the Gas Industry! I well remember my dear mother saying what a curious career I had chosen, but I have enjoyed every year I have worked in the Gas Industry. I have made many friends among you all, a good many of whom I know are here to-night. There are a great many who unfortunately are not able to be here, but I thank you all from the bottom of my heart for what you have done. It is, in a way, a mark of something that

is of supreme importance in the Gas Industry. We have had and always shall have our differences of opinion, but there is a great loyalty to our Industry as a whole. There is an absolute loyalty which overcomes all our personal differences. From time to time I look back on those long years and I think of the men whom I was privileged to know in my younger days, and who have been leaders of the Gas Industry, but who are not with us to-night—Sir Corbet Woodall, Sir George Livesey, Mr. Harry Jones, Sir Arthur Duckham, and others whom I cannot name. We are trying to carry on the many ideals which they set before us.

"Once more let me thank all my friends in this room and outside for presenting me with this portrait and my wife with this bracelet and silver. I thank you from the bottom of my heart."

Amalgamation and Grouping

New Romney and Lydd.

The New Romney Gas Light and Coke Company is to be amalgamated with the Lydd Gas Company. Both these Undertakings are controlled by the South-Eastern Gas Corporation, Ltd.

United Kingdom: Increase of Capital—

At the Extraordinary General Meeting of United Kingdom Gas Corporation, Ltd., on Nov. 4, shareholders approved the increase of capital to £6,000,000 by the creation of 500,000 4½% First Cumulative Preference Shares of £1 each, 500,000 4% First Redeemable Cumulative Preference Shares of £1 each, and 1,000,000 Ordinary Shares of £1 each.

The amount of the above capital at present issued is as follows:

	£
4½% First Cumulative Preference Shares of £1	971,097
4 % First Redeemable Cumulative Preference Shares of £1	500,000
4½% Second Non-Cumulative Preference Shares of £1	745,263
Ordinary Shares of £1	889,939
	£3,106,299
3½% Redeemable Debenture Stock	1,000,000
	£4,106,299

—and Acquisition of Broadbottom.

The Corporation has recently completed the acquisition of 86·85% of the issued capital of the Broadbottom Gas Company, Ltd., which adjoins the Corporation's Undertakings at Hyde, Denton, and Dukinfield.

Scottish Western Juniors

Visit to Tyre Works.

On Nov. 3 members of the Scottish Junior Gas Association (Western District) visited the Works of the India Tyre Co., Ltd., Inchinnan. Mr. MacKenzie extended a very warm welcome to the Association.

The company was then divided into parties and conducted round the various departments of the Works by members of the staff. A most enjoyable tour of the Works over, the members were entertained at tea by the Company.

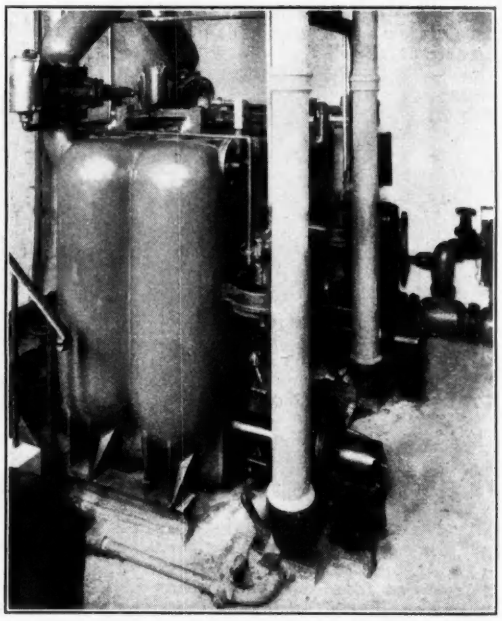
An Attractive Gas Fire Display

This striking display of Parkinson's "Super-Ray" gas fires was designed by the firm's display studios and shown recently in their Manchester showroom window.

Gas-Fired Central Heating in Schools

Increasing Load at Middlesbrough

In two recently opened Council Schools at Middlesbrough gas-fired central heating has been installed. In these two schools—Brambles and Beechwood—the system of heating is accelerated low-pressure hot water. The two boilers are "Vesta" C2 types, each of 800,000 B.Th.U. per hour rating. At Brambles School the effective radiation is 5,295 sq.ft., the volume of air heated is 252,155 cu.ft., and



The "Vesta" Boilers at Brambles School.

the approximate annual gas consumption is 2,843,200 cu.ft. At the Beechwood School the effective radiation is 4,990 sq.ft., the volume of air heated is 231,550 cu.ft., and the annual gas consumption is 3,100,000 cu.ft. Both installations are controlled by room and flow thermostats.

We learn from the Engineer and Manager, Mr. J. W. Pallister, that the number of such installations in Middlesbrough is now 57, accounting for an annual consumption of 40 million cu.ft., compared with 27 million cu.ft. in the previous year.

Southern Association of Gas Engineers and Managers

Forthcoming General Meeting

A General Meeting of the Southern Association of Gas Engineers and Managers will be held on Friday, Nov. 19, at 2.30 p.m., in the King Edward Room at the Hotel Victoria, Northumberland Avenue, W.C. 2, when a Paper will be delivered by Mr. W. A. Bishop, Sales Superintendent of the Croydon Gas Company, on "Developing the Heating Load, with Special Reference to Gas-Fired Central Heating Installations." Afternoon tea will be served at the conclusion of the meeting.

BRITISH GAS FEDERATION

THIRD . . . ANNUAL DINNER

November 3, 1937

THE Third Annual Dinner of the British Gas Federation was held at Grosvenor House, London, on Wednesday, Nov. 3—the Rt. Hon. the Earl of Dudley (President of the Federation) presiding over a gathering of nearly 900 members and guests.

LORD DUDLEY,
President of the Federation.

The Toast of " The King " having been duly honoured, the President made a presentation to Sir David and Lady Milne-Watson, which is reported in full earlier in this issue of the " JOURNAL."

"THE BRITISH GAS FEDERATION."

The Rt. Hon. Oliver F. Stanley, M.P. *(President of the Board of Trade), proposing the toast of "The British Gas Federation," said :*

I must start by saying what pleasure it gives me to be here to-night, not only at the annual dinner of the British Gas Federation, but at this particular annual dinner where we have been privileged to see the presentation which has just been made, and I think no greater tribute could be paid to Sir David Milne-Watson than the company that is here to-night. Looking through the list I see great lawyers, distinguished doctors, great municipal officers, captains of industry and political colleagues; in fact, everyone of any importance, and there is only one figure that I miss. When I came into the room I looked all round for a face whose features have become familiar to me on numerous occasions; but I could not see it. I turned to the list of those attending this function and I turned up the T's for the name of Mr. Therm. [Laughter.] I did not find it; but he is, I am sure, with us in spirit.

But I must not digress. My duty is to propose the toast of the evening, that of " The British Gas Federation." I am glad that this occasion has arisen so early in your association with the Board of Trade, because I am glad to think of the ties which to-day exist between your Industry and the Department over which I, for the present, preside. Your Industry is described in all the books of reference as a public utility, and I think, as such, it is very well described, because you do, unlike many other industries, add tremendously to the health, the well-being, and the comfort of the people. It is true, of course, that a large and, indeed, increasing share of your business is with the big concerns, providing power for great enterprises and making the motive power for whirling machinery, but to me much the most romantic side of what you do is not the assistance which you give to factories but what you do in the homes of the humble. In hundreds of thousands of homes you bring light and health and heat and cleanliness. In these many thousands of homes your Industry has brought advantages which have meant a lightened burden for the householder. Whatever discussion there may be as to the respective merits of gas and electricity, there is one feature to which you can lay undisputed claim—and that is that you are the older of the two. As I see your Industry, it has had a long history, and although other industries have had long histories theirs have not always been profitable. I am sure there is no truth in the saying " Happy the industry that has no history," because it means that the industry which has no history has nothing to write off, and what I most admire about your Industry is not the fact that it has a history but the fact that it has been able to survive it. It is not an easy task for an Industry such as yours, which for many years had little or no competition, suddenly to be faced with the keenest competition which comes from the discovery of a new source of power, to see the old monopoly destroyed and the newcomer rising, and then to be able, as your Industry has been, to fight back and to fight back with success; and, in that fight—unlike some other industries—you have not looked to the Government for help. You have looked for it where any industry which really wants a permanent basis looks for it, and that is in itself. Your record of the past few years has been a record of modernized plant, of extending your clientele from the private consumer into the domain of the factories to redress the balance of business. That has been accompanied by a great expenditure on research and by a great and continuing improvement in the quality of gas and appliances. These are the things—not Acts of Parliament—which have contributed to the successful fight which you are making, and these things are due to the initiative and courage of the members of your Industry and in no small part, therefore, are due to the members of the Federation whose health I now propose. I do propose this toast with great satisfaction, and couple with it the name of your President, Lord Dudley.

The President, responding to the Toast, said :

Although this is already the third year during which I have had the honour of being your President, it is the first time—by reason of a series of misfortunes, the first of a personal character and the second of a national one—that I have had the opportunity of presiding at your Annual Dinner, and the pleasure of replying to this Toast. However, I am a great believer in the old adage " third time lucky," and in this case it proves to be fully justified, for not only have I taken part to-night in a charming and epic presentation to two very old friends of mine, which I shall not easily forget, but also I find myself responding to a Toast which has been proposed in such a delightful way by another very old friend, the President of the Board of Trade, or as I prefer to remember him when we were a couple of grubby boys at private school, Stanley minor!

Mr. Stanley is a very welcome guest here this evening, not only on account of his personal qualities which have earned him a very well-merited popularity, but also as head of a Department with which the Gas Industry is most closely associated.

In fact, through a special sub-Department which deals with nothing else except gas administration, Mr. Stanley acts as a sort of amiable watch-dog over all the activities of the Industry. I do not know how far the Industry has suffered in the past from either his bark or his bite—whichever in his case is the worse—but I know him well enough to realize that if he did bite, his bite would leave a clean wound, with no septic consequences.

The gratitude which the B.G.F. feels to him, and to his Department, for the unremitting sympathy and assistance which they have always received from them is very sincere and deep. I am told that the advice which his Department gives us from time to time is nearly always good and that it is very seldom unnecessarily redundant. I do say now with all sincerity that I think the shining example of team spirit and good feeling which exists between Government and industry, in no case brighter than when it is lit by gas, is one of our national conditions of which we can be most justly proud, and to which is mainly due the measure of prosperity which we find ourselves enjoying to-day. It is an example from which other countries (which shall remain unmentioned) might well benefit, and it is a state of national health which could not have been brought into being without the co-operation of that splendid body, the British Civil Service, to whom we members of the Gas Industry in the presence of many of them, are proud to pay our tribute this evening.

I think we can claim that although the B.G.F. is young in years, it has learned to speak for the Industry in a voice which commands attention and respect, that it is no mere mouthpiece, but that it can act in the common interest and act with success. In fact, it has already in so short a time achieved in many respects both the position and purpose which its founders had in mind. As President of the Birmingham Chamber of Commerce, I am particularly interested in the exhibits which the Federation stages every year at Castle Bromwich. These exhibits undoubtedly show the public at large that the British Gas Industry is able to produce the widest possible selection of up-to-date apparatus at the lowest possible cost, comparable and indeed unmatched with those of any other country in the world. The Gas Industry enters into the home of every family in the land and in doing that it very naturally comes up against all those complex problems such as housing, nutrition, hygiene, domestic management, and so on, which are exercising the mind of the nation to-day. It has, I am glad to say, made a genuine contribution to public understanding of these matters and social progress in relation to them. In particular I should like to mention the splendid experiment in social pioneering which is being carried out by the Gas Light and Coke Company at Kensal House. There, through the genius of Sir David Milne-Watson, you have a housing estate complete with all amenities which compare favourably (both from an economic and practical point of view) with those which can be seen in any other country in the world.

There are many other problems which confront the Federation. Some, too, which concern another important Department over which Mr. Stanley reigns—namely, the Ministry of Mines. The mining problem is one which concerns our Industry very deeply, and we view with very great anxiety the rising costs, particularly those in regard to timber, which we observe continuing in that Industry, for indeed we realize that they are costs which will—unless checked—redound detrimentally to our own Industry. We have all noted with great pleasure the view expressed in responsible quarters that there is no evidence of a slump in trade in this country. That is certainly my view, too, but the continuance of this good trade must to some extent depend upon the wisdom with which we seek to control every tendency to any further rise in costs. It is a great problem which has to be faced right now and I think I am expressing the view of all industrialists when I say that we look anxiously to the Government at this stage for help and guidance.

I am glad to think that the progress which has been made over the last year in the development and co-operation within all sections of the coke industry is now being consolidated by the formation of a National Coke Association. I am sure we all hope that by this means there will be avoided in the future, when trade is less brisk, the foolish competition which develops when forces are unorganized and which drives prices to an uneconomic and artificially low level. But as the best preparation for dealing with a situation of that kind, I would urge that steps be taken now to put a curb upon prices rising to an artificial and uneconomic level, and that co-operation should be developed between the coke industry and its chief consuming interests on a basis that will permit and, indeed, ensure, a continuance of prosperity for both. I assure you once more of the continued desire on our side that the happy relations between us should wax even stronger and play no small part in solving some of those great problems with which the world is confronted. At a moment when our minds are so full of anxiety and our vision is blurred by so many hatreds, suspicions, and bitter divisions, it is refreshing to observe an Industry like ours working out its destinies and solving its problems in an atmosphere of such complete harmony both within its own ranks and with the consumers which it serves. We employ upwards of 120,000 persons, and I doubt if in any industry there exists a finer record of contentment and good feeling on the part of employers and employed alike. We owe that very largely to the inspiration and example of such great leaders in the Industry as Sir David Milne-Watson. By their genius and geniality they have made Mr. Therm as popular a figure as Johnny Walker—and I cannot give him higher praise. Old as it is, the Gas Industry has found the elixir of life in this spirit of unity and harmonious co-operation; thus fortified it can look forward to a lustrous future in which I sincerely hope the British Gas Federation will play no unimportant a rôle.

Sir David Milne-Watson, proposing the Toast of "Our Guests," said :

It has been my lot frequently to propose a Toast of this kind, but I do not think I have ever proposed it to a more distinguished gathering than we have here this evening. The Gas Industry, left to itself, has been able to induce very many distinguished men in all walks of life to come to our dinner to-night, where we have no cabaret or any of its subsidiaries that we sometimes hear about. A witty judge once said that good wine requires no bush—and I would also say that a good toast requires no butter. I do not propose to use any butter to-night, but I wish to say how pleased we are to have Mr. Oliver Stanley with us, representing the Board of Trade. When his predecessor came to open Gas Industries House in February, which, with the help of the Directors of the Gas Light and Coke Company, has enabled us to provide a home for the national bodies of the Gas Industry, I referred to Mr. Runciman as our uncle. We have changed our uncle and have a more youthful one now in Mr. Oliver Stanley—[laughter]—but we look to Mr. Stanley to perform the avuncular functions with the same consideration and kindness that his predecessor did. We have very many distinguished guests here and we welcome them all.

I cannot name everybody who is present, but I should like to pick out Mr. J. H. Clynes, and also my very old friend, Mr. Will Thorne. Mr. Thorne is the "grand old man" of the labour side of the Industry. I well remember the days when Mr. Thorne and I did not see eye to eye. He remembers these things as well as I do, and I will not go into details regarding our relationship in those days, but since the formation of the Joint Industrial Council I may say that Mr. Will Thorne and I have become the closest friends. He and I have worked together for many years, he as Vice-President and I as President of the Joint Industrial Council, and the result is that there never has been any national trouble with regard to labour in the Gas Industry. I think you will agree that that is a feather in the cap of the Joint Industrial Council.

The Gas Industry has all its life pursued a course of independence and has done its work quietly without Government assistance, and I think you will agree that that is one of the most important things that we have contributed to industrial life in this country. We have had our difficulties, but we have surmounted them mainly by our own efforts, and we propose to continue to do so. I should like in all seriousness to say that the Government should be careful how they make favourites of any particular industry. We all realize that it is only natural that the Government should put right anything that is wrong in any industry, but let them beware of favouritism which is just as bad in the State as in the family. It does not make for peace or harmony or utility in the long run; and there is another point in dealing with this question which is that the Gas Industry feels it must always look to the interest of the small consumer. It is a very curious thing that when a Government takes an interest in any particular industry, it is very apt to look at the well-being of the corporation and not always to the interest of the small consumers. At the same time, I would ask the President of the Board of Trade to make a mental note of the fact that the Gas Industry has always, partly by the regulations put upon it by Parliament, but chiefly by its own voluntary effort, looked after the interests of the small consumer.

In conclusion, I give you the toast of "The Guests," coupled with the name of Lord Macmillan.

The Rt. Hon. Lord Macmillan, responding to the Toast, said :

Your guests have been inspired with admiration for this magnificent organization and they have been inspired by sentiments of friendship and affection which have been expressed for the two chief figures in this evening's drama—my old friend, Sir David Milne-Watson and his wife. We have been permitted to-night to take part, as your guests, in what I suppose was almost a family ceremony, and guests who are admitted to that privilege realize their advantages. I would like to say to my old friend, in words far finer than any of my own, words used by Rudyard Kipling of one who had received a similar reward on one occasion: "Recognition by one's equals and betters in one's own craft, is a reward of which one may be unashamedly proud." The only emendation to that—you know how carping lawyers are—is that I know of no betters in the case of my friend Sir David Milne-Watson. It is to me personally a moment of very great pleasure and happiness, for I think that I and one other in this room to-night share the earliest recollections of Sir David Milne-Watson, for he and I went to the University of Edinburgh together in the year 1888, and in those immature days we had little idea of what was in store for us, but with that unerring instinct which guides the Scotsman we found our way to London. [Laughter.] Looking back on those early days we feel specially grateful for the kindly friendships which we have enjoyed in this country.

My task to-night is to convey to our hosts on behalf of this distinguished company—far too numerous to be referred to individually—their appreciation of your hospitality and their unanimous wish for your future prosperity.

Mr. H. C. Smith (President of The Institution of Gas Engineers), proposing the Toast of "The Chairman," said :

I have the privilege of proposing a toast which I know you would all like to propose—the toast of "The Chairman." This has been the privilege allotted to the President of The Institution of Gas Engineers since the inauguration of these dinners, and I feel it is a great honour. We in the Gas Industry—and I was delighted to hear Lord Dudley say "we" in making his speech—know what he has done for us and what he is always willing to do for us, and I know the guests will join the members of the British Gas Federation in drinking his health.

The President, in responding, said :

I am sincerely grateful for the way in which you have welcomed me this evening and for the manner in which you have received this Toast. I have been a very inadequate President of the British Gas Federation. It is still a source of great wonder to me how my association with the Gas Industry ever started, because, if I must let you into a secret which many of you already know, it is that my only association with the Industry is as a coalowner—and my great tragedy is that my coal does not coke! I think I offered a very handsome reward some years ago to anyone who would invent a process which would make South Staffordshire coal give a hard coke. That reward still goes, and, indeed, it is doubled. But I think my association with the Gas Industry originally started many years ago when I had the honour of being elected President of the Society of British Gas Industries. Of course, one of the duties of a President is to find a President to succeed him, and I remember the great pleasure with which I heard the announcement at the dinner of having been able to persuade Mr. Stanley's father-in-law, Lord Londonderry, to succeed me in that honourable office. Although I may not have as great claim on the British Gas Industry as most of those present, I yield to no one in my enthusiasm for the wonderful work which is carried out by the Industry and in my determination to further their ideals and ambitions to the furthest possible point.

The singing of "For they are jolly good fellows" was followed by the National Anthem, and the proceedings terminated.

New Members of the Institution

The following were elected to the various classes of Membership of The Institution of Gas Engineers on Wednesday, Nov. 3:

Honorary Membership.

Hartley, Brigadier-General Sir Harold, Kt., C.B.E., M.C., M.A., F.R.S., Chairman, Fuel Research Board, London.

Membership.

Ayre, Frank, Australian Manager, The Parkinson Stove Company (Australia), Ltd., Melbourne.

Associate Membership.

Fawkes, Stanley Victor, Assistant Engineer, Yorktown (Camberley) and District Gas and Electricity Company, Camberley, Surrey.

Gale, William Alfred, Draughtsman, Smethwick Gas Department.

Garside, Raymond Bancroft, Technical Assistant, Grantham Gas Company.

Grammer, John Murray, Deputy to Officer in Charge of Training, Gas Light and Coke Company.

Hawkings, Bernard George Henry Joseph, Assistant Distribution Superintendent, Plymouth and Stonehouse Gas Light and Coke Company.

Healey, Arthur, B.Sc., Shift Engineer, Oldham Gas Department.

Heath, Charles Williamson, Assistant Works Chemist, Stoke-on-Trent Gas Department.

Horner, Arthur Smith, B.Sc., Engineering and Technical Assistant, Wallasey Gas and Water Department.

Kay, George Wilkie, Assistant Engineer, Selby Gas Department.

Keene, Charles Joseph Percival, Assistant Works Chemist, Barnet District Gas and Water Company.

Mear, Norman, Member of Technical Staff, W. C. Holmes & Co., Ltd., Huddersfield.

Milner, Geoffrey, B.Sc., Ph.D., Technical Assistant, Ashmore, Benson, Pease & Co., Ltd., Stockton-on-Tees.

Monson, Gilbart East, Carbonizing Superintendent, Plymouth and Stonehouse Gas Light and Coke Company.

Murray, Graham Francis James, B.Sc., Assistant Sales and Fittings Superintendent, Sheffield Gas Company.

Newton, George, Works Manager, Hollinwood Station, Oldham Gas Department.

Pepper, Richard John, Service Supervisor, Fulham Offices, Gas Light and Coke Company.

Reed, Charles Arthur Edward, Technical Assistant, South Shields Gas Company.

Sanders, Malcolm Jack, Technical Assistant and Chemist, Newton Abbot and District Gas and Coke Company.

Taylor, Frank Martin Hussey, B.Sc., Ph.D., Technical Adviser, Headquarters Sales Department, Gas Light and Coke Company.

Whiting, Richard, Engineering Assistant, Commercial Gas Company.

Wilkinson, John, Shift Engineer, Leeds Corporation Gas Department.

Associateship.

Fowler, Leonard John, B.A., Research Engineer, Ideal Boilers and Radiators, Ltd., Hull.

Law, Roland Kay, Assistant Engineer and Manager, Marple Gas Department.

Rodgers, George Hooper, Divisional Mains Superintendent, East Central Division, Gas Light and Coke Company.

Taylor, James Buckley, Technical Assistant, Stretford and District Gas Board.

Williams-Thompson, Richard Barton, Staff Officer, Publicity Department, Gas Light and Coke Company.

THE "JOURNAL" REVIEW OF THE Institution Research Meeting

Nov. 2 and 3, 1937

Excellent attendances and full discussions marked all the sessions at the Autumn Research Meeting of The Institution of Gas Engineers, held last week at the Institution of Mechanical Engineers, London, under the Presidency of Mr. H. C. Smith, M.Inst.C.E.

THE meeting commenced on the stroke of ten on the Tuesday morning, and Dr. W. T. K. Braunholtz, who recently assumed the duties of Secretary of the Institution, was received with applause when formally introduced by the President, Mr. Harold C. Smith. The first item on the programme was the presentation of the 1936-37 Report of the Gas Education Committee. In the unfortunate absence, due to illness, of Sir Francis Goodenough, Chairman of the Committee—to whom a message of good wishes was sent from the meeting—the Report was introduced by the Vice-Chairman, Mr. John Terrace. Reference to the new Regulations affecting those engaged on the supply side of the Industry was made by Mr. Terrace, who explained that their object is to make the Education Scheme available to the varying requirements of those engaged in the Industry. The standard of the Higher Grade Certificate on the supply side has been raised, and it will rank equally with the Certificate in Manufacture as one of the qualifications for admission to Corporate Membership of the Institution. The new Certificate in Gas Supply, said Mr. Terrace, is available to meet the growing need of those not aspiring to a certificate requiring such high academic standards as the Higher Grade and those not at present engaged on the practical, as distinct from the clerical, side of the Industry.

Mr. F. C. Briggs, who seconded the adoption of the Report, spoke of the frequent revision of the Regulations which had been necessary since the inception of the Scheme to render it generally acceptable, and he offered to the Principals of Technical Institutions the Committee's apology for the trouble caused and thanks for their help and forbearance. In regard to the new Regulations Dr. J. N. Long, Head of the Westminster Technical Institute, spoke of the suddenness with which they had been introduced, a rapidity which had caused considerable embarrassment, and he urged that the Council of the Institution should make it clear what is meant by the "practical" side of the Industry. As things stand at present, because of this lack of definition, students and also gas undertakings are under considerable difficulty in deciding whether a man is, or is not, on what may be termed the appropriate side of the Industry. Mr. R. N. LeFevre also commented upon the speed with which the change in the Regulations had been made.

The value of the Short Courses arranged for teachers of gas subjects was emphasized by several speakers during the course of the discussion, Dr. P. C. L. Thorne, of the Board of Education, asking that gas engineers and managers should make it possible for those of their staffs who so desired to attend these Courses. Another high light of the discussion was the desirability of part-time day training, more than one speaker maintaining that the employer would do well to consider whether at least some measure of this training should not be made available to the student, instead of his being compelled to do his studying in the evening, when his energies are necessarily at their lowest. Mr. LeFevre explained what the Gas Light and Coke Company is doing in this regard.

Presentation of Diplomas.

FOLLOWING discussion on the Education Report Diplomas were presented to the successful candidates. In Gas Engineering (Manufacture) the awards were: E. F. Gorman, 1st Class; S. T. Jones, 1st Class: J. K. Mitchell, 1st Class; G. J. Rimmer, 1st Class; and F. N. Tidball, 2nd Class. Three Diplomas in Gas Engineering (Supply) were awarded: F. Bell and B. G. H. J. Hawkings gained 1st Class Certificates and G. G. Warne a 2nd Class Certificate.

Alteration to By-Laws.

THE President then reported that the alterations to the By-Laws of the Institution had been allowed by the Privy Council. He explained that the Council are now in a position to recommend the members of the Institution to admit many technical workers who are doing valuable work for the Institution and the Industry and who will undoubtedly be welcomed in the ranks of the Institution's members. Mr. Smith explained that at a Council meeting that morning the following alternative Regulation under by-laws 13 (*b*) (1) and 14 (2) had been determined:

> "An applicant for Membership or Associate Membership of The Institution of Gas Engineers shall possess a B.A. or B.Sc. Degree of a British or approved Empire University in the post-Matriculation Course for which, in the opinion of the Council of the Institution, a competent standard of knowledge has been attained in at least two of the following subjects—*i.e.*, chemistry, engineering, mathematics, or physics."

Thus, said Mr. Smith, any applicant for membership of the Institution who possessed the other qualifications required by the By-Laws and who also possessed a qualification which came within the foregoing Regulation was now eligible for membership of the Institution without possessing the Higher Grade Certificate. He hoped that the many technical workers in the Industry who must be covered by this Regulation would feel that if they made application for membership it would be very carefully and sympathetically considered.

Presentation to Mr. Alexander.

AT this stage in the proceedings the President made a presentation on behalf of the Institution to the former Secretary, Mr. J. R. W. Alexander, as a mark of esteem on the occasion of his resignation. The presentation was in the form of silver, and was accompanied by a bound list of names of the members, approaching 500 in number, who had subscribed. Mr. Alexander was invited to the platform and was greeted with prolonged applause.

The President, in making the presentation, said that Mr. Alexander was appointed Secretary of the Institution in December, 1929, at a time when the internal affairs of the Institution were completely disorganized. He handed over the affairs of the Institution to his successor in June of 1937 in a state of complete and efficient organization. "We shall," said Mr. Smith, "inevitably benefit from the results of his work for many years to come, a fact which I know Dr. Braunholtz would be the first to acknowledge. Mr. Alexander's retirement coincided with my election as your President and I am particularly grateful to him for his keen sense of duty, which was so admirably displayed at that time and of which I am very glad to have this opportunity of making a public acknowledgment."

At the conclusion of his gracefully expressed thanks for the gift, Mr. Alexander read a letter he had received from an anonymous donor of 100 guineas as a contribution to the Institution Benevolent Fund, and handed the cheque to the President, who asked Mr. Alexander to express to the donor the sincere thanks of the members of the Institution.

Changed Plan of Research.

THIS brought us to the presentation of the 40th and the 41st Reports of the Joint Research Committee of the Institution and Leeds University. As Chairman, Mr. E. V. Evans introduced the Reports, pointing to

the fundamental change in the type of work undertaken under the Committee's direction. "If," remarked Mr. Evans, "your Committee were called upon to frame terms of reference, I think they would be something like this: 'To develop yet more efficient methods for the scientific treatment of coal, to cheapen the cost of gas manufacture, and to explore the possibilities of the Gas Industry supplying a very much larger volume of motor spirit and fuel oil in the future.' That, of course, is a very ambitious programme, and I fear that the patience of the practical gas engineer may often be very sorely tried. But I should like to add a note of warning and to tell you that the investigations now being undertaken by your chemists at Leeds are of the nature of pure research, and they cannot be expected, as was formerly the case, to be sure of industrial application. Some of their work will lead to culs-de-sac, and you will be disappointed if you expect all the chickens of the Joint Research Committee to lay eggs. Yet in the 41st Report of the Joint Research Committee there are indications of some promise. I do not think that, twelve months ago, any of us would have given much credence to the statement that something like two-thirds of a charge of semi-coke could be gasified in hydrogen to yield a gas containing over 30% of methane and having a calorific value above 500 B.Th.U. per cu.ft. To the chemists, the developments with which this Report deals are full of interest and there is very much room for speculation on the question of the mechanism by which hydrogen combines with the coal in the process of decomposition by heat. Hydrogen reacts not only with gas coals, but with a wide range of coals, differing as widely as lignite and semi-anthracite. This observation we consider to be of the greatest importance from the point of view of the Gas Industry and from that wider point of view of the national coal resources."

Referring to the complementary work described in the 40th Report, Mr. Evans observed that newer methods of gas manufacture will be useless unless the gas so made is capable of being used satisfactorily in the very many appliances which the consumer to-day demands. The Gas Industry, of course, must be allowed flexibility in its choice of manufacturing process, but that flexibility must be achieved without interfering with the service we give to our consumers. We know all too little of the effect of change of gas quality, and we should really understand this matter in much greater detail. We may learn that certain gases are far more suitable for our public, or we may learn that the appliances and burners need modification in order to deal with a wider range of gas quality. It is not altogether for the future that we require this knowledge. Gas undertakings do require to-day to change the quality of their gas. It may be a temporary change, brought about by the relative demands for gas and coke, or it may be a permanent change due to a change in carbonizing installations of a new process such as the simultaneous removal of sulphur and benzole. It is a fact that to-day we are not able to predict exactly what will happen to the consumers' appliances when the change has been made, and it is this state of ignorance which the Joint Committee's investigation is intended to remove.

Combustion Characteristics of Town Gas.

THE 40th Report of the Joint Committee is largely a synopsis of the information available upon gas quality, combustion characteristics, and burner performance, and is intended to show what points may be regarded as definitely established, which require supplementary investigation, and to what extent gaps in existing knowledge require to be filled. The review is divided into a number of sections dealing respectively with rate of flame propagation in mixtures of gas and air, aeration of burners, design and use of test burners, and suggested criteria for representing the combustion characteristics of gases. From a consideration of the data collected it seems clear that although considerable attention has already been given to combustion characteristics and the principles of burner design there is a real need for further experimental work in obtaining more comprehensive data, so that the available results of laboratory tests may be effectively utilized in connection with practical gas burner problems. Suggestions are put forward regarding the lines along which future investigations should be conducted.

The survey of the literature upon test burners has been supplemented by a preliminary experimental examination of the Aeration Test Burner. The behaviour of this instrument towards pressure variation, the behaviour of representative gases over a C.V. range of 300 to 700 B.Th.U. per cu.ft., the relation between aeration, air-shutter opening, and specific gravity of gas, and a number of miscellaneous points arising in its manipulation are included. The Aeration Test Burner works most satisfactorily over the C.V. range 400 to 500 B.Th.U. per cu.ft., and the examination does not reveal any outstanding manner in which the design could be improved.

Dr. Harold Hartley, who opened the discussion on the Report, said that to him it seems doubtful whether any recording of a bunsen cone height for an arbitrarily chosen air-gas ratio or of an air-gas ratio which gives a particular cone height in a single test burner can provide an adequate measure of the influence of composition changes on the completeness or otherwise of the combustion attainable in apparatus in use on the district. He suggested that the composition of the interconal gases and the secondary air requirements of flames produced at different degrees of primary aeration may have a direct influence on the combustion results attained with appliances using bunsen flames. It would, he said, be helpful if some indication could be given of the extent of the variation in composition of typical town gas supplies which may have to be made for manufacturing reasons under present-day conditions, and especially if arrangements could be made for series of experiments to be carried out in selected works.

Reference to the criticisms levelled at the Ott burner was made by Mr. F. O. Hawes. It is quite true, he remarked, that it is not an instrument of such precision as the Prufbrenner or as the Aeration Test Burner. However, by individual calibration such as the A.T.B. itself demands, it can be made sufficiently correct for practical purposes. There is no point in having a scale of such fineness that it will indicate differences insignificant in practice, such as differences for ordinary changes in atmospheric conditions. There is some evidence that the Aeration Test Burner is open to these objections. "It is mentioned in the Report," he observed, "that a single figure to indicate combustion characteristic is what is required. Frankly, I think we shall waste time if we continue to seek for this. The flame speed curves of various air-gas mixtures are not parallel, and therefore no single figure can tell us all that we need to know of a gas."

Hydrocarbons from Coke.

THE 41st Report of the Joint Committee describes further experiments in connection with the investigation of processes of gasification for the production of gas suitable for general distribution. It is concerned with the synthesis of gaseous hydrocarbons and especially with the possibility of promoting the synthesis by operating at high pressure. The study of the production of gaseous hydrocarbons has been separated from that of the initial gasification to hydrogen and carbon monoxide although, in a process depending upon subsequent reactions at high pressure, avoiding compression charges would probably require the initial gasification also to be made under pressure.

The first high-pressure experiments were made within conditions anticipated for a fuel bed undergoing gasification and were designed to see whether a synthesis of hydrocarbons could be expected to occur in the upper part of the bed to the same extent when using British coals as in the Lurgi process using lignite. Thus, a mixture of hydrogen, carbon monoxide, carbon dioxide and undecomposed steam, such as would be produced near the base of the fuel bed by the initial gasification reactions, was passed at 50 atmospheres pressure over various cokes heated to 800° C. The gas mixture was supplied at a rate equivalent to the gas output of a modern water gas plant and the cokes were made from lignite, semi-anthracite, and weakly caking and strongly caking coals. It was found that after treatment the gas had a considerable methane content which was not greatly dependent upon the type of coke so long as this had not suffered severe heat treatment during its preparation. In particular, the lignite coke did not appear to be specially favourable for methane formation.

The results of the preliminary experiments indicate that, in general, all types of bituminous coals, as well as lignite, can be gasified in steam under pressure with the synthesis of hydrocarbons in the fuel bed and the production of gas of a sufficiently high calorific value for general supply. It appeared that most of the methane formed in the preliminary experiments was the product of direct combination of the coke with the hydrogen contained in the mixture of gases supplied and was not due to interaction of hydrogen and carbon monoxide. The hydrogenation of solid fuels to gaseous hydrocarbons plainly required a thorough investigation, and the experiments described in the main part of the Report were made for that purpose.

The experimental procedure adopted is described and typical results are given. Striking results were obtained by heating the coke in hydrogen at pressures above atmospheric. There were remarkably high yields of gaseous hydrocarbons. At 5 atmospheres the yield was equivalent to 92·1 therms per ton, at 10 atmospheres 132·9 therms, at 25 atmospheres 202·5 therms, at 50 atmospheres

276·0 therms, and at 100 atmospheres 311·2 therms. At 50 and 100 atmospheres there was evidence of an increased yield of tar.

Some experiments were made on heating coke in mixtures of hydrogen and carbon monoxide under pressure, and it was found that as high a thermal yield of gaseous hydrocarbons could be obtained with the mixtures as with hydrogen alone, if the rate of supply of the mixture and its pressure were increased so as to allow for the lower percentage of hydrogen in the gas supplied. While loss in the thermal yield was avoided by this procedure, dilution with carbon monoxide led to a gas of lower calorific value.

The discussion was opened by Dr. J. G. King, who remarked that the production of even one extra therm of gas per ton of coal has always been of importance to the Industry; how much more important is the discovery, in this research, of a means of gasifying a further 50% of the coke. The practical importance of the discovery and in what manner it shall best be utilized are still to be determined, and will involve such difficult questions as the relative importance of gas and coke markets, the supply of hydrogen, and the design of a large-scale plant to make the best use of the discovery. Mr. T. Campbell Finlayson called to mind that other industries have found the need for a gas consisting predominantly of hydrogen and that many millions of cu.ft. of gas are made per day containing over 85% hydrogen. Whether or not this is a cheaper gas in comparison with a gas richer in carbon monoxide for operating the type of hydrogenation process outlined in the present report ultimately turns on yield and quality of the final product. May it not, therefore, he suggested, be well to keep in mind that in the production of the final enriched gas ready for distribution there are two avenues of approach each of which use the same ingredients—viz., air, water, and coal. The first avenue depends upon the compression of a large volume of air in order that one-fifth of the volume—the oxygen—may be made available for gasification of the coal under pressure, followed by the hydrogenation of the coal by the mixture of hydrogen and carbon monoxide to produce the final gas for distribution.

The second avenue depends upon the complete gasification of coal at atmospheric pressure in either a one-stage or a two-stage process, using the necessary oxygen from the air without any power or capital cost; this would be followed by the conversion of water gas by the standard process to a gas largely composed of hydrogen, compression of this hydrogen, and, finally, hydrogenation of coal by means of this gas with the formation of a final gas rich in hydrocarbons and hydrogen and low in carbon monoxide.

Mr. T. F. E. Rhead mentioned that in translating the work into practice gas engineers are rather concerned about the high-pressure apparatus needed and the cost of compressing the gases. It has occurred to him that we really get pressure for nothing. If we carbonized our coal in a suitably constructed heat-resisting steel retort and allowed the pressure to build up to the desired degree, should we not get self-hydrogenation?

Removal of Sulphur Compounds.

THE session on Tuesday afternoon was devoted to discussion of three Papers on the removal of sulphur compounds from gas by Mr. H. Hollings, Mr. W. K. Hutchison, and Dr. R. H. Griffith, of the Gas Light and Coke Company. Mr. Hollings reviews briefly the various processes for the removal of sulphur compounds —viz., the active carbon process, the normal oil washing process, an oil washing process in which the oil is regenerated by treatment with alcoholic caustic soda, and the catalytic process. During recent years, he observes, the successful large scale removal of sulphur from gas has been dependent upon, and in no small measure incidental to, the removal of benzole from gas. When the active carbon process was introduced it represented a striking advance in the technique of benzole extraction quite independently of the circumstance that so much of the sulphur was removed from the gas. More recently the thermal efficiency of the oil washing process has been improved by the adoption of improved heat exchange auxiliary plant and, at the same time, the advantage of distillation under reduced pressure has been realized. These advantages in the oil washing process may be applied to the recovery of benzole quite independently of sulphur removal. It appears desirable, therefore, that at an early date we should consider the merits of the catalytic purification of gas as a preliminary to the oil washing process as well as a preliminary to the carbon process.

Mr. Hutchison describes at length the oil washing process with a short review of the development of the process from its inception in 1927 to the completion in February, 1937, of a plant at the Kensal Green Works of the Gas Light and Coke Company, designed to treat 7 million cu.ft. of coal gas per day. He considers the concentrations of the different sulphur compounds in gas obtained from various sources and the necessary properties of the wash oils to be used in their extraction. A detailed consideration of the performance and design of the plant which incorporates distillation under reduced pressure, is given, and the results obtained, including the efficiencies of various units of the plant, are shown.

The third Paper, by Dr. R. H. Griffith, gives a detailed description of the removal of sulphur compounds by a catalytic process in which the gum-forming nitric oxide is also removed, including a description of the preparation of the catalyst, the apparatus used, and the results obtained by the process.

Opening the discussion, Mr. E. V. Evans commented on the swiftness with which Mr. Hollings and his colleagues have reduced the practicable limits for the desulphurization of gas. "From discussing ways and means of reducing the sulphur content to 10 grains per 100 cu.ft., Mr. Hollings has in no more than a year moved to the point of showing us the possibility of producing gas containing only one or two grains per 100 cu.ft. The work also that Mr. Hutchison has carried out in improving the oil washing process is really an outstanding example of the advances that are possible in established processes when they are painstakingly analyzed by physical chemists and then reconstructed with knowledge and imagination." As to the important discovery by Dr. Griffith, Mr. Evans said he had renewed his belief that there is great cause for gratification in that research work in the Gas Industry is not left in any one pair of hands or with one group of workers. Is there not in the result of this work, asked Mr. Evans, the answer to those who advocate the formation of an all-embracing and all-inclusive research institute which might enshrine and even embalm the best brains of the country?

Dr. E. W. Smith, maintaining that the question of sulphur removal is probably the most important matter the Gas Industry is tackling to-day, emphasized that if we can use gas in controlled quantities for space heating without any smell of sulphur we have a most effective weapon for extending the use of gas. In regard to the economic aspect, Dr. Smith would like to have, in any given example, the relative costs of making gas without benzole extraction; secondly, with benzole extraction; and, thirdly, the cost of gas-making with benzole removal and extraction of carbon bisulphide. The more one goes into the Reports of the Research Committees and reads the communications issued by the Gas Light and Coke Company, remarked Dr. Smith, the more one feels that they ought not to be thrown into the pit for people to take them out and drop them as they think fit. There ought, he said, to be some directive power within the Industry to indicate a broad policy for gas engineers. Dr. E. Schindel made the point that, whereas Mr. Hutchison has shown that it is possible by extremely careful design to achieve results in sulphur extraction and energy consumption approximating to those of the carbon plants at present installed in this country, it should not be forgotten that the carbon adsorption process, by reason of the fundamental physical principles, possesses a greater margin of elasticity, and sulphur extraction can be carried economically with this process still further, whereas "the results reported by Mr. Hutchison must represent an upper economic limit beyond which, in the present state of knowledge, it will be difficult to go." Mr. G. Claxton, regarding the problem from the benzole producers' point of view, said that sulphur in benzole is an unmitigated nuisance; and from this aspect the catalytic process of sulphur removal from gas has definite attractions. Mr. C. Cooper suggested that in Mr. Hollings' Paper there appears to be undue emphasis on the actual cost, chiefly the steam cost, of the desulphurizing process based on oil washing and distillation. Sulphur extraction, he said, will stand some actual cost, on its merits, and in the average case need not pay as a manufacturing process.

Pipes Committee Report.

THE first item on Wednesday morning was the presentation by the Chairman, Mr. H. J. Escreet, of the Report of the Pipes Committee. This Report, he said, draws attention to the new B.S. Specifications for Cast Iron Pipes and for Rubber Joint Rings for Gas Mains. The former specification is a revision of the 1917 Specification and will cover a wider range of sizes and additional special castings—including Horseley syphons and flat taper pipes. The Specification for Rubber Joint Rings will, he thinks, enable the flexible types of joint to be used with greater confidence—the life of these joints is entirely dependent upon the type of rubber used, and in view of the difficulty of testing rubber, the purchase to specification should prove of great advantage.

Section II of the report deals with co-operation between

the Post Office engineers and the Gas Industry so far as their underground plant is concerned. The agreement with regard to access to jointing chambers extends to the whole country arrangements which have been in force for a number of years—in an unofficial way—in the larger towns, and this will be found to be mutually advantageous. A detector for carbon monoxide is described in the Report. It is inexpensive and easy to operate and may serve as a useful auxiliary to the various types of indicators already in use. It is not intended to be used for tracing escapes of gas, nor is it intended to supplant existing types of indicators, but it is certainly useful for proving the absence of town gas in underground pits, &c. Finally, with regard to the Wrought Iron Specifications, Mr. Escreet said he had been asked why these should be revised when there is a decided tendency to use steel pipes in place of wrought iron. The answer is that many still prefer wrought iron, and if the Institution is to be responsible for a Specification then that Specification should be kept up to date. The proposed addition of a specification for wrought iron bars is intended to complete the specification by ensuring that fittings are made from the same type of material as the tubes. It is also proposed to bring the specification for tubing into line with the new B.S. Specification for Wrought Iron Pipes (Screwed and Socketed) which will be published shortly.

Three representatives of the Post Office took part in the discussion on the Report, and the view was expressed that great good will come from the co-operation, indicated in the Report, between the Gas Industry and the Post Office. In regard to co-operation generally, Mr. P. Richbell, of Croydon, wondered, now the Committee has been so successful in making the arrangements set out in the Report with the Post Office Authorities, whether a similar arrangement could be made with the London Passenger Transport Board. This, he suggested, would be very useful to distribution engineers in charge of distribution systems in the area of this Authority. In regard to the carbon monoxide detector described in the Report, Mr. A. B. Densham mentioned that a disadvantage of the instrument is that it is impossible to test for carbon monoxide in the presence of hydrogen sulphide, though the latter can be tested for separately. Mr. C. R. Austen spoke of the wide dissimilarity in the composition and shape of rubber joint rings and of the fact that many gas undertakings and manufacturers have their own special methods of preparing the joints. It had been possible, therefore, to standardize only the quality of the rubber used; and to cover adequately rings of different design, the specification caters for rubber rings of three distinct types—soft, medium, and hard. The tests specified necessarily involve the use of rubber testing apparatus, but they have been limited in number and severity to cover only the specific requirements of each of the three types.

Gasholder Maintenance.

THIS brought us to the Report of the Gasholder Committee, which was presented by Mr. Thomas Hardie. This is the last report of the Committee as such, as it is now merged in the Gas-Works Safety Rules Committee. The requirements of the new Factories Act, which comes into operation in January, are mentioned in the Report, as far as gasholders are concerned. Mr. Hardie does not think they will be found to press unduly on any undertaking; indeed, they are such that we can put them into force with the feeling that it will be of definite benefit to us to do so. Many holders in use to-day have already had a long life and yet they do their work so well that we are inclined to think they are as good as when first installed. Those holders which have received proper maintenance and for which conditions of working have been normal throughout will, in fact, be almost as good as new. In many cases the maintenance or the conditions have not been all they should have been, and examination will show that, in spite of smooth operation, repairs are necessary to ensure safe working. Many tests of the sheeting of holders have shown that little, if any, deterioration in the quality of the sheets takes place through age alone. Deterioration may, of course, take place from other causes.

The regular examination of the holder and the keeping of records required by the Act have been urged for years by the Committee, who have now prepared record sheets for the assistance of those who have not yet already prepared record forms.

During the discussion on the Report, Colonel W. M. Carr emphasized that the responsibility of gas engineers is in no way lessened by the Factories Act.

The next item on the programme was to receive a Paper on the Low-Temperature Carbonization of Scottish Cannel, by Dr. J. G. King and Mr. James Jamieson. This was published in the "JOURNAL" for Oct. 13 last. There was no discussion on this Paper.

Gasholder Purging.

MR. F. M. BIRKS then presented his Paper on Purging Gasholders by means of Inert Gas. The plant described in the Paper originated in the United States of America and was first introduced into this country in 1934. A description of the plant and its mode of operation is given. The inert gas consists of the products of combustion from a suitably adjusted gas burner which pass from a refractory-lined and water-cooled combustion chamber to the inlet main of the gasholder. Inert gas is passed through the gasholder until all combustible gas has been removed; the inert gas is then displaced by air. This process is reversed when the holder is put back into operation. Figures are given for the quantities of gas and water required to operate the plant, the composition of the inert gas, the proportion of inert gas required for the production of non-inflammable mixtures, the toxic limits for carbon monoxide and hydrogen cyanide, and, finally, the costs of the process.

It is difficult, says Mr. Birks, to generalize in regard to the cost of purging with the inert gas plant, but if this is of such character that air blowing plant is necessary the only cost additional to that normally incurred is of the transport of the purging machine and the provision of the necessary gas and water connections, the cost of which will, of course, depend upon local conditions. The operating costs in themselves are low. The cost of inert gas is about 8d. per 1,000 cu.ft. with town gas at 2s. per 1,000 cu.ft. dependent to some extent upon the cost of water. The operating costs amount to between £2 and £10 per holder, dependent on its size. As an example, the cost of purging a holder by the usual means and by the purging plant has been estimated, and the approximate increase in cost is some £50. With a medium or large sized holder this £50 represents a small proportion of the whole cost of carrying out an internal inspection and repair.

The machine has also been used to purge gasholders other than those quoted and also to enable difficult welding operations to be performed. In one case a long length of overhead steel gas main had partially failed at the welded joints; a complete repair was effected by welding mild steel strips over the joints while the main was kept under a slight pressure of inert gas. The machine is also being used to inflate a water gas relief holder with inert gas while extensive repairs are being undertaken by means of welding. No difficulty has been experienced in operating the machine, but it has been found to be somewhat cumbersome, and it is proposed in the near future to split it into two or more sections in order to make it more easily portable.

"Purging," said Mr. E. G. Stewart in the course of the discussion on the Paper, "opens up a new era to the gas engineer. The putting into and out of service of holders and similar plant can be performed with its aid with an absolute elimination of hazard in the most densely occupied areas. Operations involving welding can be extended to fields where hitherto it would have been dangerous to introduce a flame. Fire in closed vessels, such as oil tanks, purifiers, and the like, can be easily controlled, while finally the engineer who has once employed purging will, I am certain, extend the use of it to more and more operations on gas apparatus. The cost is small when peace of mind alone is considered; from the point of view of an insurance premium it is absurdly low. . . . Intelligent application of purging should mark the commencement of a new standard of safety in gas practice."

Mr. A. E. Williams, Chief Engineer to the Commercial Gas Company, expressed the opinion, after three years' use of the Harrison machine, that it is only a question of time for some form of apparatus for the production of inert gas to be included in the standard equipment of all the larger undertakings. Mr. D. M. Henshaw explained that with the assistance of Mr. Birks his firm are redesigning the purging machines with the idea of making them a little more compact, and possibly putting them on two vehicles instead of on one. Further, they are developing a machine which can be hired—and, of course, such a machine must be made as transportable as possible.

Retort House Governing.

A PAPER on Retort House and Exhauster Governing was presented by Mr. G. Dougill. In this are described the devising and perfecting of an instrument for recording governor performance. An account is given of work in connection with relay governors, including methods of curing "hunting," the design of a new governor system for coke oven exhausters, and the evolution of an improved bell type, direct acting retort house governor. Items for general consideration in the choice

and design of a governor system are given, particular reference being made to the lay-out of the impulse pipe which is an important part of the system, and the Paper concludes with a review of the advantages of accurate governing.

There is little doubt, said Mr. Dougill, that the use of anti-dips and the so-called "dry" receiving mains emphasizes the need for good governing, since the foul main now has a direct connection with the retort. In former days, when a liquor seal was interposed, accurate control was hardly so important because, owing to unequal settlement, &c., the seals varied from end to end of the hydraulic main and so prevented the advantage of accurate governing from being observed.

However, the query has often been raised whether accurate governing really pays. Objections are based on the fact that an accurate governor is usually more expensive in first cost and maintenance. It is also pointed out that, as horizontal retorts are in three to five tiers, the lower retorts require different pulls from the upper retorts, and of course a similar effect is operative in coke ovens and vertical retorts.

Although it is impossible to obtain incontrovertible figures to show that improved governing has paid an exact sum, it can be shown that excellent governing may be obtained, by careful choice and design, at very little increased first cost or maintenance. Under these conditions, the objection that full advantage of good governing cannot be utilized because of the design of retorts falls to the ground, as the maximum improvement possible is always better than none. Another very solid advantage is that a further variable or unknown factor is removed from the retort house, a factor which all gas engineers will appreciate, when the therm yield is down. Any saving in therms must, of course, be some proportion of those formerly lost and will vary according to the age and condition of the plant. The most important aspect of good governing, however, is the favourable effect on the retort or oven walls. A steadily maintained pressure of the right value enables cracks and pores to seal by the deposition of carbon, minimizing the wear and tear at these weak places, and it is felt that the maintenance of the settings in sound condition is one of the most valuable results of good governing.

Mr. B. R. Parkinson, in the discussion, said he was glad that Mr. Dougill had made clear that perfection in governing is theoretically impossible; for the simple reason that deviation from perfection is the only possible operative force leading to restoration. The task is to reduce this deviation to a minimum, just as we can reduce the inertia of working parts in a governor to a minimum and also reduce friction, but we cannot entirely eliminate them.

Ignition by Cold Catalyst.

THIS brought us to the Paper on the Ignition of Gas by Cold Catalyst, by Messrs. L. W. Andrew, A. B. Densham, and E. W. Voice. This Paper, presented by Mr. Voice, is divided into two sections, the one dealing with the catalyst itself, and the other with its application to appliances. The early history of catalytic ignition starting in 1817 leads up to a detailed consideration of the design of the modern catalyst. This catalyst can be obtained from a Continental or British source and consists of a pellet of finely divided platinum, intimately mixed with refractory, supported on a platinum wire. It is shown that the present design is essentially satisfactory.

The optimum strength of gas-air mixture and gas rate over the catalyst are discussed. The main reasons for delay in ignition or failure to ignite are poisoning by small concentrations of sulphur compounds in gas and by sulphur dioxide and water vapour in the atmosphere. Research is proceeding on the development of a pellet which will be less sensitive to poisoning.

It has been established that the most important factors to be considered in applying the catalyst are isolation of the catalyst from products of combustion and control of the gas-air mixture and gas rate over the catalyst. Some of the early housings were unsuccessful because they did not fulfil these conditions for optimum operation. The controlling factor in design was found to be the complete absence of products of combustion. This was first achieved by the use of flame lift from a horizontal pilot, but better results were obtained by off-setting the catalyst, removing the products through a small flue, and using a balanced flue to ensure ignition when hot, or by arranging that the gas is only on momentarily. Housings embodying these principles were applied to gas fires and cookers in considerable numbers and were considered for other types of appliance. As a result of the experience obtained, a housing was developed which is considered to be completely satisfactory.

Experience has now been obtained in the laboratory for over three years, and district experience is available on 180 experimental housings; also this is the second heating season for 4,000 commercial gas fire housings on the Gas Light and Coke Company districts. It is for this reason that although the work on the cold catalyst is by no means complete and is still being continued actively, the information gained is sufficiently promising to be made generally available.

The present position, using a British catalyst and a housing of correct design, is that reasonably satisfactory ignition will result. The worst that can happen is occasional failure to ignite on abnormally cold and foggy days when the appliance has not been in frequent use. If, however, the appliance is then ignited by means of a match the catalyst automatically recovers its normal activity. The research which is being carried out on the catalyst, concluded Mr. Voice, makes it hopeful that this poisoning effect will shortly be overcome and then the cold catalyst should be a completely reliable and completely simple general method of ignition of gas.

Effluents and Ammonia.

THE first item on Wednesday afternoon was the presentation by Mr. C. F. Botley of the 7th Report of the Liquor Effluents and Ammonia Committee. In doing so Mr. Botley explained that since 1926 investigation and research have been diligently conducted in the problem of the disposal of effluent and the allied matter of ammonia production and utilization. During the same period large gas undertakings and leading manufacturers have also been concerned, and generally the Committee have been favoured with information as to such developments. Although many further points could and should receive investigation, a stage has been reached when the knowledge acquired can be utilized with practical advantage and, this being so, the Council of the Institution desires that, with its limited means and important matters requiring attention, the Committee's Research Chemists should be utilized in other directions, and thus the direct research has, for the time being, come to an end. It is said for the time being, because the Council desires the Committee to continue in being (indeed, its present work is not completed) so that the members can be called together from time to time in case of any urgent problem or fresh development.

A manual or text-book is in course of preparation, following the work of the Committee and others, and this, it is hoped, will be of practical use to engineers and managers who have or may have trouble in connection with ammonia or effluent problems. A recent Act has been placed on the Statute Book, which, while not affecting what has been done, clarifies the position of the use of sewers by traders, including, of course, Gas Undertakings in the future. It is probable that in connection with this Act and the by-laws which may be prescribed by various local authorities, members of the Institution may need advice and assistance, and such will be available.

The Report deals with tests on the gas liquor concentration plant at Coventry, the crystallization of concentrated liquors, and the relationship between density and composition of concentrated liquors.

Refractory Materials.

THEN came presentation of the 28th Report of the Refractory Materials Joint Committee. Before calling upon Mr. W. Grogono to introduce the Report the President paid a tribute to the work of Dr. Mellor as Director of the British Refractories Research Association. Mr. Grogono called attention to the reconstitution of the Council of the Association, explaining that the Gas Industry now has eight seats instead of four. He also mentioned that there has been an alteration in the method by which the Department of Scientific and Industrial Research grant is paid to the B.R.R.A. This was on the basis of £1 for every £1 of income in excess of £3,000, with a limit of £3,000. There is now a block grant of £4,000 in respect of the first complete £5,000 subscribed, no grant being made if subscriptions amount to less than £5,000, and a further contribution of £1 for every £1 subscribed over £5,000 and under £7,000 in units of £100.

As the new Director of the B.R.R.A., Mr. A. T. Green introduced the Report. In it experiments are described which disclose that dry town gas, freed from carbon dioxide, causes the disruption of firebricks susceptible to disintegration much more rapidly than dry town gas containing 3·5% of carbon dioxide. In these, as in previous experiments, the silica specimens were not broken down. With the dry, CO_2-free gas the tendency to disintegration

decreases with the temperature of exposure, and disruption was not, in fact, observed at 700° C. or lower temperatures. Experiments with ethylene at 600° and 800° C. indicate that hydrocarbon does not cause the mechanical breakdown of firebricks. Polymerization to benzene and more complex hydrocarbons occurred. It is concluded that methane is the constituent of coal gas which is primarily responsible for the disruption of firebricks at 800° to 900° C.

The investigation commenced in 1936 on the mechanical stability of cement joints in tension or under compression up to temperatures of about 1,400° C. has now been extended to include silica cements containing ganister and crushed silica brick in admixture bonded either with lime or with a mixture of lime and clay. Results are also reported for mixed calcined and uncalcined kyanite-clay cements. Two Papers are included on various aspects of the action of alkali vapours on refractory materials. The first is concerned mainly with observations of the expansion induced in fireclay materials exposed to the action of potassium chloride vapour at 1,000° C., while in the second the action of the vapour from two sodium aluminates on clay and silica refractories at temperatures ranging from 900° to 1,200° C. is described.

An account is given of investigations of the action of slags on refractory materials. The results obtained by three contrasting methods of testing have been correlated and a study has been made with the petrological microscope of the specimens resulting from the tests. A Section on the Refractoriness-under-Load test deals with the maintained temperature—increasing load test, and deformation-load-time curves have been used to record the behaviour of the materials tested. An investigation has been made of the effect of additions of sodium and calcium phosphate to silica brick batches, in order to ascertain whether conversion of quartz to tridymite rather than cristobalite is favoured. The properties of some sillimanite products of high porosity prepared in the laboratory have been investigated, and experiments made with the object of developing materials of high refractoriness but low heat capacity and thermal conductivity.

The Report includes a contribution by Mr. A. Edwards (Gas Light and Coke Company) on Clay Bonded Silica Refractories in Segmental Horizontal Retorts, in which the behaviour of retorts built with a clay-bonded siliceous material (91 to 92% SiO_2; 5 to 6% Al_2O_3) is compared with retorts in the rest of the house constructed in lime-bonded silica.

Research in General.

MR. E. V. EVANS was then called upon to present the 3rd Report of the Research Executive Committee. Following this Sir Harold Hartley, who has been elected an Honorary Member of the Institution, expressed his appreciation of the honour and congratulated the Committee on the valuable series of Communications placed before the meeting. He was a believer in having a number of units working at our problems. "I always think," he remarked, "that if you have a number of centres each intellectually independent, you are much more likely to get new ideas and you are much more likely to get that sort of individual development on which, after all, progress in research depends. What we need is a great deal more research. I think the optimistic side of that is that if you had had a meeting like this 10 years ago you would not have had anything like the amount of material to discuss, so that I am sure that great progress is being made; but I think it is important to make everybody realize that research necessarily is rather costly. Modern research, which requires a technique, is getting more refined, which means that the expenditure is necessarily bigger. Therefore, I think the endowment of research must be on a liberal scale. It is, I think, essential that the Gas Industry should be looking ahead and should take care that a sufficient proportion of money which is being spent on research should be spent on fundamental investigations. It seems to me the Institution has a valuable part to play in making the application of research easier. It is no good just doing the work and getting the results embodied in a series of valuable Reports unless you make the application easy. For big undertakings which have large engineering and scientific staffs the problem is, of course, simple, but, after all, the strength of the Industry depends on the general strength of all its undertakings, and when you come to the smaller undertakings it must be realized that it is much harder for them to make the adjustments and to apply the knowledge that is given to us in these Reports. Therefore, I would suggest that that is a function which this Institution might usefully perform."

Vote of Thanks.

THE meeting closed with an omnibus vote of thanks to all who had contributed to the success of the meeting. This was proposed by Mr. W. W. Townsend and seconded by Mr. D. M. Henshaw. Response was made by the President and by Dr. Braunholtz.

French Gas Industry

Review of the 60th Congress of the Union Syndicale de l'Industrie Technique du Gaz en France

Continued from p. 366.

Supply of Medium Pressure or Compressed Gas to Small Undertakings

E. Carrière referred to the fact that economic conditions in France often necessitate the shutting down of the manufacturing activities of small undertakings and the provision of a supply of gas from a larger Gas Company. In all cases, arrangements must be made to secure that all consumers are served. Depending on the quantity of gas involved and the distance, the new supply may be provided by means of a transmission main or in compressed form in cylinders with road transport.

The Author developed certain basic ideas. The line of the principal feeders should be alongside the sites of large industrial consumers to whom gas must be supplied at a low tariff. The pipe-line should pass as close as possible to the junction of arterial roads where the compressor stations destined for the charging of the mobile cylinders may be installed. Depending on the position of the centre of the production of gas, subsidiary feeder mains may be provided. These can be of very small size in relation to that of the principal main if the zone traversed is not an industrial one. Where necessary, a booster station may be installed.

The undertakings situated along the route of the feeder main would, irrespective of their size, be supplied by way of reducing governors without the intermediary of a holder. More remote undertakings would be supplied from branch mains with the aid of boosters, if necessary, while areas still more remote would be supplied from lorries carrying compressed gas.

Depending on interest rates, the choice may lie between mains of small diameter with a high emission pressure or mains of larger diameter and a smaller pressure. It is possible to plan the necessary pipe diameters throughout the system on a rational basis though it must be borne in mind that in sections where the consumption is small the size of diameter is governed not by the pressure drop but by a certain minimum beyond which it is not wise to go. In view of the fact that condensates and blockages do not occur at a distance exceeding 10-12 miles from the emission station, this minimum diameter may be as small as 2 in. for branch mains connected to the feeder main at a point at least 10 miles from the station or even 1¾ in. when the distance is still greater.

The next point is to decide on the nature of the pipe line. The choice lies between welded mains, cast iron mains with rubber gaskets, and Eternit mains. Considerations to be taken into account include the working pressure, the size of the system (length and pipe diameter), and the lengths in which the mains are available. With short sections, for example, rubber gaskets would not be suitable for benzolized gas. Experience gained during four years by the Société Bethunoise d'Eclairage et d'Energie with a distribution system comprising 90 miles of feeder mains has shown that welded steel mains give rise to but an insignificant loss by leakage.

The distribution system itself serves as a holder in a high pressure system but holders existing in shut-down works constitute a means for the regulation of the output of a station and may be charged at suitable hours by the distributing company. Where, however, it is necessary to provide a holder at the supply station, the holder should be of the high pressure type and should be capable of withstanding the pressure generated by the compressors.

Where road transport of compressed gas is involved, the position of the filling stations should be judiciously planned with a view to the maximum utilization of the lorries. The small undertakings which have to be supplied should be provided with high pressure holders in addition to any ordinary holders which may be available.

(*To be continued.*)

PRESENTATION TO

J. R. W. Alexander

Acknowledgment of Services Rendered

The President made a presentation on behalf of the Institution to its former Secretary, Mr. J. R. W. Alexander, as a mark of esteem on the occasion of his resignation. The presentation took the form of silver, and was accompanied by a bound list of names of the members, approaching 500 in number, who had subscribed.

The PRESIDENT, in making the presentation, said that Mr. Alexander was appointed Secretary of the Institution in December, 1929, at a time when, owing to a variety of circumstances, the internal organization was (if one might so describe organization) completely disorganized. He handed over the affairs of the Institution to his successor in June of this year in a state of complete and efficient organization. They would inevitably benefit from the results of his work for many years to come, a fact which Dr. Braunholtz would be the first to acknowledge.

Mr. Alexander's retirement coincided with Mr. Smith's election as President, and he was particularly grateful to him for his keen sense of duty which was so admirably displayed at that time and of which he was very glad to have this opportunity of making public acknowledgment. The Council felt that it would be the wish of members to express in a tangible way their gratitude to Mr. Alexander for the valuable work which he had done on behalf of the Institution.

The silver is engraved with the following inscription:

> "Presented to John Russell Willis Alexander by the Members of The Institution of Gas Engineers in appreciation of the loyal and valuable service rendered by him as Secretary of the Institution from 1929 to 1937."

Mr. C. S. SHAPLEY (Past-President) also spoke of Mr. Alexander's work and expressed the hope that he would live long to enjoy the gifts which they had been pleased to give him. He was very glad to think that one of his last duties as Secretary was so to frame the By-Laws that they could admit him as a member of the Institution.

Mr. J. R. W. ALEXANDER, acknowledging the presentation, remarked that they would forgive him if he asked them all to "Accept my thoughts for thanks, for I have no words." He was privileged to be entrusted with a task by this Institution. He did no more than anyone in that room would have done.

Since leaving this Institution he had been happily engaged in dual occupations of, should he say, a benevolent character in the South of England. He had, in fact, entered the gas fraternity properly so called; and the kindness which he had received in the past had continued to that very moment. Only that morning he received a letter which, without mentioning names, he asked permission to read. It was as follows:

> "Dear Mr. Alexander,
>
> "I recently read with interest of the considerable progress made by the Benevolent Fund of the Institution during the time you were its Hon. Secretary, and to mark that expansion and encourage yet further development, I would ask you to accept with my good wishes the enclosed cheque for 100 guineas as a contribution to the Fund."

Mr. Alexander presented the cheque to the President, and concluded by saying that those magnificent gifts to him would ever remind him of his service with the Institution; they would afford, he hoped, inspiration to his family for generations to come; and in accepting them with gratitude he sincerely reaffirmed his devotion to the Institution and its members, for "Let the man who would be grateful think of repaying a kindness even while receiving it."

The PRESIDENT asked Mr. Alexander to thank the anonymous donor of the cheque very sincerely on behalf of the members of the Institution.

The Coke Oven Managers' Association

Annual General Meeting

The Annual General Meeting of the Association was held in the Hotel Victoria, Northumberland Avenue, W.C. 2, on Oct. 28. Mr. T. JOHNSON (the retiring President) occupied the Chair during the early part of the proceedings.

The Report of the Council for 1936-37, having been circulated, was taken as read; there was no discussion on it, and on the motion of Mr. E. M. MYERS, seconded by Mr. G. A. HEBDEN, it was adopted. Mr. E. M. MYERS thereafter moved the adoption of the accounts and balance-sheet, which was seconded by Mr. C. P. FINN, and unanimously adopted. Mr. E. M. MYERS proposed and Mr. W. FORSTER seconded the adoption of the Benevolent Fund Account.

Election of Officers.

The HON. SECRETARY reported that the following had been elected for the ensuing year: *President*, G. W. J. Bradley; *Vice-President*, J. Curry; *Hon. Treasurer*, P. B. Nicholson; *Hon. General Secretary*, F. White.

New President.

Mr. T. JOHNSON, before vacating the Presidential Chair, expressed his very best thanks to the officers of the Association for the assistance they had rendered him during his year of office. He mentioned particularly the Hon. Secretary and his assistant, and the Hon. Treasurer. He said that without the able assistance of the latter the Association's finances would not be in the present sound condition. Mr. Johnson then introduced his successor, Mr. C. W. Bradley, and wished him success during his year of office.

Mr. BRADLEY expressed his appreciation of the honour accorded him and went on to propose a hearty vote of thanks to Mr. Johnson for his services as President during the past year.

His Presidential Address was then delivered by Mr. Bradley, to whom a cordial vote of thanks was accorded on the proposition of Mr. P. B. NICHOLSON, seconded by Mr. G. A. HEBDEN.

The Autumn Research Meeting

OF THE

INSTITUTION OF GAS ENGINEERS

THE PRESIDENT,
H. C. Smith, M.Inst.C.E.

Thirteen Reports and Papers were presented and discussed at the 9th Autumn Research Meeting of The Institution of of Gas Engineers, which was held at the Institution of Mechanical Engineers in London on Nov. 2 and 3, under the Presidency of Mr. H. C. SMITH, M.Inst.C.E.

14th Report of the Gas Education Committee, 1935-36

Communication No. 164

Included in this Report are the names of successful candidates in the 1937 Examinations of the Institution, as published in the "JOURNAL" for July 21, p. 179; the Questions set in the Examinations, published in the "JOURNAL" for May 5, p. 272; and also the Report of the Examiners—see "JOURNAL" for July 21, p. 181.

The 1937 Revision of the Education Regulations (Publication No. 160) embodying all amendments made to the Regulations up to and including 22nd June, 1937, and superseding all previous issues, is now available and can be obtained from the Secretary of the Institution. The import of the chief amendments as they affect the administration of the Regulations are given below.

From the 1st October, 1936, a Second Class Higher Grade Certificate in Gas Engineering (Manufacture) or Gas Engineering (Supply) became sufficient for entry to the Diploma Examination in Gas Engineering (Manufacture) or Gas Engineering (Supply) respectively.

Candidates for the Diploma Examinations of the Institution who cannot produce the usual Educational Certificates or other satisfactory evidence as to the standard of their general education, are now required to submit themselves to an Examination conducted by the Institution.

The following additional amendments, to which the attention of Principals of Colleges is particularly drawn, have been made to the 1934 Revision of the Education Regulations:—

(1) The terms "Gas Engineering (Manufacture)" and "Gas Engineering (Supply)" have been substituted in all three Grades for the terms "Gas Engineering" and "Gas Supply."

(2) (*a*) The standard of the Higher Grade Certificate in Gas Engineering (Supply) has been raised, so as to accord with the standard of the Higher Grade Certificate in Gas Engineering (Manufacture), by requiring that the Ancillary Subjects to be taken shall be of equivalent standard to those required for the Higher Grade Certificate in Gas Engineering (Manufacture).

(*b*) The Higher Grade Certificate in Gas Engineering (Supply) is now recognized as being equivalent to the Higher Grade Certificate in Gas Engineering (Manufacture) for the purpose of complying with By-Law 14 (2) for admittance to Associate Membership of the Institution.

(*c*) A Candidate for the Higher Grade Examination in Gas Engineering (Supply) must at the time of entry be suitably engaged on the *practical* side of the Gas Industry in Gas Engineering (Supply).

(*d*) In view of the higher standard for the Higher Grade Certificate in Gas Engineering (Supply), no additional Ancillary Subjects are now required for the Diploma Examination in Gas Engineering (Supply).

(3) There is an Examination for a Certificate in Gas Supply, primarily intended for Candidates not engaged on the practical side of the Gas Industry. This Certificate does not (i) comply with By-Law 14 (2) for the purpose of admittance to Associate Membership of the Institution or (ii) admit to the Diploma Examination in Gas Engineering (Supply).

The Syllabus is similar to that required for the new Higher Grade Certificate in Gas Engineering (Supply), together with the Ancillary Subjects previously required under the 1934 Revision of the Education Regulations for the Higher Grade Certificate in Gas Supply.

(4) The Certificate in Gas Supply is convertible to the Higher Grade Certificate in Gas Engineering (Supply) by the Candidate passing the necessary additional Ancillary Subjects and being or having been suitably engaged on the practical side of the Gas Industry in Gas Engineering (Supply).

Introduction.

Mr. J. TERRACE, in presenting the Report of the Gas Education Committee, said: My first reference must be to the regretted ill-health during the latter part of the year of the Chairman, Sir Francis Goodenough. This has prevented him from taking his usual part in our deliberations. He is not able to be with us to-day and I am sure you would all like to join the members of the Committee in wishing him speedy restoration to health and strength.

During the year there has been a notable change in the Regulations affecting those engaged on the Supply side of the Industry and these are set out clearly in the Report. They are the result of much discussion and constitute a big step forward. They have for their object a desire to make the Education Scheme available to the varying requirements of those engaged in the Industry. Unlike the previous revision of the Regulations (1934) they have

raised the standard of the Higher Grade on the Supply side of the Industry, the new standard being that required on the Manufacture side. The new certificate in Gas Engineering (Supply) will thus rank equally with Gas Engineering (Manufacture) as one of the qualifications for admission to Corporate Membership of the Institution. To meet the growing need of those not aspiring to a certificate requiring such high academic standards and those not at present engaged on the practical as distinguished from the clerical side of the Industry the new certificate in "Gas Supply" is available. The examination in the main subject being the same as that of the Higher Grade Certificate in Gas Engineering (Supply) it can be converted to the latter if and when the additional qualifications in ancillary subjects and in employment are attained. A revision of the Syllabus for these examinations is in hand and as you will see in the Report a Moderator of the Question Papers has been appointed. He is our old friend Mr. C. H. Creasey, who has been a member of the Education Committee since its commencement, first as a Representative of the Board of Education and now as a Representative of the Institution, and appreciative comments on his work as Moderator have already been received. At the first annual Gas Education Conference there was a general feeling that the new constitution was satisfactory and that the new body was an improvement on the Consultative Committee which it had replaced.

The first Short Course for Teachers in Gas Fitting held at Birmingham was a great success and requests for another have been received. About the same time the London County Council by arrangement with the Gas Light and Coke Company held a similar course in London at Watson House. It also was well attended. When it is noted that the number of examinees in Gas Fitting last year exceeded 2,000, the desirability of facilities for Teachers' Courses in this subject is very apparent and the Committee greatly appreciate the action of the Board of Education in arranging those Teachers' Courses. The Committee has noted with much satisfaction the extension of activity in several of the District Education Committees. These Committees form a valuable link between the student and the Education Centre and their work is much appreciated.

Mr. F. C. Briggs (Dudley), seconding the adoption of the Report, said: The Gas Education Committee has been described as one of the most important, if not the most important, of the Institution's Committees. This must be true as it has to do with the quality of the personnel which is entering and has to carry on our industry in the future. It is certainly a Committee which constantly and consistently deals with a very large amount of work, which has no limelight and no glamour, and lacks the interest which technical Committees have for technical men. Nevertheless it remains a very live Committee and exhibits no signs of the conservatism to which an education committee might quite easily fall a victm. It is constantly endeavouring to make its rules and regulations fit the necessities of the student and of the Institution, and not make the student fit into cast-iron regulations. This necessarily brings the Committee a large amount of detail work. It has also in the past, unfortunately, entailed a frequent revision of the Regulations. This must have caused some trouble and maybe a little annoyance to our friends and helpers the Principals of Technical Institutions. To them I offer the Committee's apology for the trouble caused and thanks for their help and forbearance. May I also appeal for their continued forbearance? The Education Scheme itself is only some thirteen years old—a mere child. The Institution itself is the fourth engineering institution in this country in order of seniority, but only recently has it acquired the dignity of a Charter, and the responsibilities which that status brings has necessarily affected the Education Scheme. In the first thirteen years of its life a child must necessarily grow and change rapidly, but normally the changes that follow are less and slower. It is hoped, therefore, that while further changes may come in the Regulations they will be less extensive and less frequent.

The general education scheme has been devised and operated mainly with one particular class of student in mind, the youth who leaves a secondary school between sixteen and seventeen years of age, and immediately starts practical training in the Industry, continuing his technical education in evening technical institutions. There is a doubt creeping into the minds of many whether this is the best scheme either for the youth or the Industry. The value of education being continued by daytime university training after the secondary school is being increasingly recognized. More of this type of student are becoming available, and more are being absorbed into the Industry.

The Education Scheme is sufficiently elastic to cater for such students. It enables them to obtain credit for the work they have done, but at the same time redresses any lack of balance, from the point of view of the Gas Industry, there may have been in their previous training. But neither the supply of, nor the demand for, university degree students, is at the moment great, and it appears that for some time the present system will continue. If it does there are matters that deserve serious consideration. The employer would do well to consider whether at least part-time day training should not be made available to the student instead of his being compelled to do all his studying in the evening when his energies are at their lowest. There are, of course, difficulties of which time does not permit a discussion here, but the whole matter deserves mature thought.

The student in his anxious endeavour to progress as rapidly as possible needs to consider the desirability of what I would call for want of a better phrase general cultural and personality training. I do not scorn the young man in a hurry, for the early start may be half of the race; and with the demands of the Institution's Education Scheme to meet in the spare time left after full-time practical training probably at mechanics' hours, there is very little spare time or energy left maybe for anything but essential exercise and recreation. But it is essential to remember that junior positions in the future will need a higher standard of knowledge than in the past for the same position, and that progress to senior positions must depend not only upon the technical knowledge to which the Institution's Certificates testify, important as that is, but to a broad outlook, an ability to foresee problems and solve them with wisdom, and to a personality which commands the respect of those whose energies will be directed. I say this not to decry the very important work of the Committee, but to direct the students' attention to the fact that while theoretical technical knowledge is essential, it is only one of the essentials of success.

Discussion.

Teachers' Courses.

Dr. P. C. L. Thorne: I should like mainly to call your attention to the evidence which the Report provides of the continued vigour of the Gas Education Committee. The widespread alterations in the Regulations are not the result of the cranky ideas of a few professional educationalists, but have been developed by the Committee from the suggestions of the Industry itself, and I hope the Committee will always be as responsive to the needs of the Industry as it has been in this particular instance.

I should like also to refer to what I think we might call the servicing work of the Education Committee, and I would refer first to the Teachers' Courses, because they represent one of our very important lines of fortification. We have attempted not to teach the teachers the technical matter but to give them some ideas on the methods of teaching. With that end in view, a Course was held in Birmingham this year, and there was a corresponding Course in London, both of them for teachers of gas fitting, who have been a good deal neglected in the past. A similar Course is to be held next year in Birmingham, not on exactly the same lines, but embodying such alterations to those lines as experience has shown to be desirable. Apart from the expense of getting to Birmingham and living there in a very cheap but delightful hostel for a week, no fee is charged for the Course. There are difficulties, of course, in getting the time off, and I would ask gas engineers and managers to be generous in this matter to those of their staffs who are engaged in teaching and to make arrangements for them to be spared as far as possible for the week if they desire to attend the Course, and indeed to encourage them in every possible way to attend the Course.

So far as ordinary every-day work of instruction is concerned, the Report shows that there has been a good deal of revision of courses. This under-pinning and constant improvement takes up a very great deal of the time of the Gas Education Committee. So far as the examination entries are concerned you may have noticed with alarm that there have been fewer entries this year for the major courses. I should be the last person in the world to neglect a matter such as that. But I have been in technical education long enough to realize that a variation of *plus* or *minus* 10 per cent. in any year can be completely inexplicable and can be completely reversed during succeeding years. Perhaps it is rather bold of me to ask you to wait and see; but I have seen the students in the classes, and I think you will find that next year and in succeeding years the numbers will go up again. So long as we remain round about the 400 mark for the major courses we need not worry about the present state of the Industry. A very important fact which has reduced the numbers is that hitherto a number of people have entered again for the same examination in order to get a first-class certificate,

but have not done so this year because that is not now necessary to enable them to proceed for the Diploma. That is one of the results of the revision.

As to the minor courses, there has been a continuous decline of entries for Gas-Works Practice. I think you will agree that probably the people for whom this course was devised no longer exist in any large number. But the Gas Supply Practice and Gas Fitting courses maintained their numbers. The Gas Fitting course, which I had thought had reached its peak, has now exceeded the 2,000 mark.

What is Meant by the "Practical" Side?

Dr. J. N. Long (Westminster Technical Institute): Mr. Terrace is slightly in error when he says that there are students in your Industry who do not wish to join the Institution. It is a fact that all the students I have come across, whether engaged on the practical, the technical, or the clerical side of the Industry, want to get into the Institution. I suggest that you should not make two special courses for the Gas Engineering (Supply) Examination, but that you should have a common five years' course to be taken by all the students. I was gratified by, and was very pleased to accept on behalf of my colleagues the principals of technical colleges up and down the country, the apology for the change of Regulations. In the middle of July the Institution materially altered the Regulations and made them operative as from Sept. 1. Unfortunately, however, I have to make financial and staffing arrangements some time in April each year for the succeeding session, and the rapidity with which your new Regulations became operative resulted in really considerable embarrassment, because my prospectus was printed and contained the old Regulations, and the new students came along with the new Regulations in their hands and asked what about the new ancillary subjects. We have not really got over the situation yet.

There is another point I should like to mention, that you must make absolutely clear what you mean when you refer to the "practical" side of the Industry. You really do not mean "practical," but you mean "technical and/or practical," perhaps. Students are in considerable difficulty, as are also gas undertakings; and your own Committee, by reason of some of these decisions, is in considerable difficulty in deciding whether or not a man is on what I call the appropriate side of the Industry. The point is rather important, and there are some members of gas undertakings here this morning who have received letters from me asking for reconsideration of some of the information they gave me about their pupils and others who are entering. The interpretation of that single word has caused us considerable embarrassment.

An Embarrassing Position.

Mr. R. N. LeFevre: The scheme, coming as it did without any warning, placed the students in a somewhat embarrassing position. They naturally want to embark on the new scheme forthwith, and a fourth year student, about to commence his fifth year, finds himself short of two necessary ancillary subjects which he can only make up in the majority of cases by working five nights per week during the coming session. I know, and I have told the students, that they are no worse off than they were; for really they ought to follow the normal Course and do an additional year. Human nature being what it is, however, one can only expect them to get through as quickly as they possibly can.

I am glad that Mr. Terrace and Dr. Thorne have referred to the Teachers' Course held in London. It was in no way intended to be competitive with the Board's Course, but supplementary to it. The dates covered different periods, so that teachers in London who wished to attend the Board's Course, and teachers in other parts of the country who wished to attend in London, could do so, and both Courses were equally successful. It is to be regretted that that was not referred to in the Report. The Committee's Report is used by all of us who are intimately connected with the scheme as a sort of guide-book, in conjunction with the Institution's Hand-Book, and we use these two books considerably. It is a pity that the Report omits the Gas Fitting Examinations and the examinations in the minor Courses, for it would be better to have all the examinations for which the Institution is either directly or indirectly responsible combined into the one Hand-Book.

Reference has been made by Mr. Briggs to part-time day education. In that connection my Company has recently modified completely its scheme of training for boys, so that all boys entering the Gas Sales Department nowadays do not enter as apprentices, but as trainees, there being a two-years' probation during which everyone of them attends a technical institution one whole day a week. If at the end of two years the boys are satisfactory they will be indentured as apprentices. It means that at the moment we have more than 300 boys attending part-time day classes. No vocational training is attempted at these classes but, in their third year, the boys who are indentured spend the whole year on full-time vocational training at Watson House. The Education Committee has approved this year as being equivalent to the first two years of the evening course in gas fitting.

At the moment it would appear both impracticable and undesirable for part-time day vocational training in gas subjects to be undertaken by educational authorities. It is difficult to release qualified teachers who are employed by Gas Undertakings and, in many cases, it would be equally difficult to release students in the major courses who, by the time they reach the final years are usually engaged in responsible work. After all, it is no hardship for such personnel to study in the evening.

The young lad of from fourteen to sixteen years of age presents a different problem, however, and deserves our sympathetic consideration.

Mr. C. H. Creasey, O.B.E.: We should be very glad indeed if we could adopt the suggestion made by Dr. Long. We are not anxious to introduce more complications than are absolutely necessary to make the scheme sufficiently elastic to meet the needs of all kinds of students. Although the scheme perhaps looks a little complicated, and although there is more complexity than Dr. Long likes to see in it, the position with regard to Gas Supply students is that none of them who were satisfied with the old scheme need change at all; all students who were dissatisfied with the old scheme, because it did not give their ambitions full rein, can change over to the new. But we cannot change over from one standard to another without a little extra work, and those who wish to take advantage of the greater opportunities afforded by the new scheme will have to devote, as a rule, another year in order to reach the highest standard in ancillary subjects. I do not think that less than that can be expected. When we undertook this revision we found that there were some people in the country who were perfectly satisfied with the old scheme and did not wish to change, whereas others wanted the scheme to provide greater opportunities. We left the first type free to follow their bent, and we gave opportunities for the other type. The scheme is very much simpler than it looks when set out on paper in a series of Regulations.

It is very satisfactory to feel that after fourteen years of the scheme we are receiving bouquets; we did not receive them at all in the early days. The great danger is that when a scheme is working smoothly one feels that everything is all right and that it is not necessary to make any changes. But in an industry such as the Gas Industry it has been quite impossible to stand still, and we have had to make revisions every two or three years right from the beginning. Perhaps those who are in the Industry do not notice the changes so much. Those who remember the early scheme and who know the scheme of to-day will realize that very big changes indeed have been made. We are glad to have made them and to have undertaken the work thereby involved, because we believe that every one of the changes made has been of benefit to the students and to the Industry in which they are engaged.

Rewarding the Fitter.

Mr. Walter T. Dunn (late Secretary of the Institution): I wish to call the attention of the meeting to the desirability of giving full recognition to the gas fitters, and I would suggest to the Committee that it might be to the advantage of the Industry if the success achieved by those men were recognized by Institution awards. Our sister Institution in France does that sort of thing. I do not put that forward as the reason why we should do it; but we know human nature well enough to appreciate the value of an incentive, and I think you will agree that it would be a great incentive to our gas fitters to realize that for their work they might receive an award at the hands of the President of this Institution. We have many friends in connection with the Universities of the country. Cannot we take some steps with a view to securing recognition for our measures by the University authorities? That is done in other cases; for example, the Institute of Secretaries has a connection with the Universities. When you contemplate the attitude of the public and the effect of raising the status of the gas engineering profession, I think you will be satisfied that this suggestion is worth consideration.

With regard to evening classes, I would say with great respect to those who run them so admirably that I do not think it is fair to expect young men, after working hard all day long, to attend such classes and slave away until perhaps nine or ten o'clock at night. I speak with some experience of this matter in my younger days. The men should have a chance, as Mr. Briggs has rightly said, to cultivate arts such as music and other things which we

understand as culture; surely they are entitled to some leisure time in which to cultivate those arts, and such cultivation will have an effect on their general demeanour, which is important when they have to meet customers. The question of address means very much to the progress of the Industry and the Institution.

Mr. Terrace Replies.

Mr. JOHN TERRACE, in reply, said: I had made a note to commend to your very special attention the remarks made by Mr. Briggs concerning daytime courses; without flogging the subject too much—and it has already been mentioned again by Mr. Dunn—I hope engineers will give it their consideration.

A common certificate has been suggested by Dr. Long, but I think that that point has been dealt with adequately by Dr. Thorne. Dr. Long rather suggests that we do not know what we mean when we refer to the "practical" side of the Industry and he suggests that we mean the "technical" side; he suggests that even that does not fill the bill, and that nobody knows exactly where we are. I hope the Council of the Institution, who have already discussed this thing at considerable length, will continue to try to make up their minds what course to take.

It has been pointed out by Mr. LeFevre that certain things have been omitted from the Report. The only reason for that is that the Report is made by the Gas Education Committee of The Institution of Gas Engineers, and although the minor courses come into our general scheme, they are really conducted by the City and Guilds of London Institute. The information he has asked for could quite easily be included in the Report, however, if desired. Reference to the gas teachers' course, which was held in London, was omitted from the Report for the same reason. Finally, I can assure Mr. Dunn that his suggestions will have the careful consideration of those concerned.

40th Report of the Joint Research Committee of the Institution and Leeds University

Combustion Characteristics of Town Gas.

Research Chemists: James W. Wood, M.Sc.Tech., A.I.C.; F. J. Dent, B.Sc., Ph.D.

Research Assistants: W. H. Blackburn, Ph.D.; A. H. Eastwood, B.Sc., Ph.D., A.I.C.; H. C. Millett, Ph.D.

Communication No. 166

GENERAL INTRODUCTION BY THE LIVESEY PROFESSOR, JOHN W. COBB, C.B.E., B.Sc., F.I.C.

The work of the Joint Research Committee during the past twelve months has received the full consideration of the Committee and of its Chairman, Mr. E. V. Evans, with the object of focusing activities upon problems of the first importance to the Gas Industry. In laying its plans the Committee has interpreted its function as being not only to satisfy obvious and urgent needs of the present time, but also to take a longer view along the lines of possible or probable future developments.

There has been established during the last few years a consensus of opinion among those most intimately concerned with the utilization of gas in appliances that, in spite of the large amount of work which has been devoted to the subject, there remains a very real necessity for further searching investigation. The factors influencing qualitatively and quantitatively the combustion of gas in a domestic or industrial appliance are numerous, and the result of their combined operation is exceedingly difficult to forecast. It is, however, of the utmost importance that, in some way or another, what are known as the combustion characteristics of a gas should be made subject to measurement and numerical expression in such a form that the behaviour of the gas in a domestic or industrial appliance can be forecast with confidence when these measurements have been made. This is in essence the problem which the Committee is setting out to solve. In doing so, the number of possible programmes of experiments each with its own justification is so great and the amount of experimental work bearing more or less directly upon the problem is so large, that a very careful choice has to be exercised in order to advance upon a line of definitely useful investigation which will yield the information and guidance required. For this purpose, and to avoid needless repetition of work already done, the Committee decided that as a preliminary to experimental work, the extensive literature bearing on the subject of combustion characteristics of town gas in one way or another should be summarized and critically reviewed so as to deduce from it what might be taken as established and useful on the one hand, or doubtful and comparatively irrelevant on the other. This has been done by the Research Chemist, Mr. J. W. Wood (assisted by Dr. A. H. Eastwood), and the review which they have prepared is, after discussion by the Committee, now presented as the main part of the 40th Report of the Committee. It is a lengthy document, but in the opinion of the Committee it forms such a comprehensive survey of existing knowledge of the subject, of a kind that has not been previously made, and contains so much useful information from widely scattered sources, that its publication in full is more than justified.

In an Appendix is given a bibliography of the numerous papers and publications which have been consulted in the preparation of the review, headed by a short list of papers dealing more specially with combustion characteristics. The review is of a comprehensive character and deals sectionally with rate of flame propagation in mixtures of gas and air, aeration of burners, design and use of test burners and suggested criteria for representing the combustion characteristics of gases. There remains, however, in the opinion of the Committee, a real need for further experimental work before the results of laboratory tests can be fully and effectively utilized in the solution of gas burner problems. It is, for example, desirable to know the conditions under which typical burners will back-fire, extinguish by blowing off, or give rise to noise or imperfect combustion, when supplied with gases the combustion characteristics of which have been determined with an accepted test burner, or defined in some other way yet to be ascertained. A start has already been made by an examination of the behaviour of Aeration Test Burner No. A.124 under varying conditions, and with gases of different qualities.

The Joint Committee has recently with great regret received the resignation of Mr. E. V. Evans as its Chairman on taking the Chairmanship of the Research Executive Committee of the Institution. During his comparatively brief tenure of the office, Mr. Evans has shown a keen interest in all the doings of the Committee, guiding its work with judgment and understanding.

STATEMENT BY THE CHAIRMAN OF THE JOINT RESEARCH COMMITTEE, E. V. EVANS, O.B.E., F.I.C.

The belief of your Committee that the most useful type of work to be undertaken under its direction is that aimed towards solving the problems which may be expected to arise in the years ahead has influenced our programme not only on the side of Gas Manufacture but also on the side of Gas Utilization. Variations in the relative demand for gas and coke require that the Gas Industry should have the greatest possible flexibility in manufacturing processes, but we regard it as unquestionable that this flexibility should be achieved without interfering with the service which we give to the gas consumer.

It may not be amiss to give an example of the type of problem in the solution of which the information we are seeking would be of great value. There exists today quite a wide range in the calorific values declared by different Undertakings and there are indications of a trend, which may be accentuated by closer co-operation, towards a narrowing of this range. When the time comes for any Undertaking to contemplate a change of calorific value consideration has to be given to the effect of the alteration upon the performance of some thousands of gas burning appliances. The change in calorific value will probably involve a concomitant change in the specific gravity, and the hydrogen, methane, carbon monoxide and inert content will probably alter also. Will the aeration of the burners, the freedom from noise, and completeness of combustion be adversely affected? These are questions we should be able to answer with certainty and we believe that the investigations now commencing will enable us to

do so. Possibly the processes of manufacture which we are to-day exploring will result in the production of gas behaving differently in appliances from the gas which is at present supplied, and, realizing that we know all too little about the effect of changes in the composition of gases in relation to their behaviour in appliances, we have considered this a most fruitful field to explore. As the work develops it may show that certain possible processes of production are unacceptable because the nature of the gas produced may be such as to limit its use in appliances. On the other hand, we may learn that the appliances themselves need to be designed on somewhat different lines in order that they may accommodate a greater range of gas quality.

SUMMARY

If a single property must be used for assessing the quality of town gas, calorific value is unquestionably the one to be adopted. It can be determined rapidly and with reasonable precision, thereby facilitating control during gas manufacture, and it is fundamentally related to the principal purpose for which town gas is required—namely, the production of heat.

The Gas Undertakings of this country have for years been accustomed to supplying gas to a calorific value specification, but there is a growing volume of evidence to show that if the best results are to be consistently obtained from modern gas appliances, constancy of calorific value alone is not sufficient. It would appear that the rate and manner of combustion of a gas are only second in importance to the actual amount of heat developed, yet at the moment there is no general supervision in this respect. The omission may be due to the difficulty of satisfactorily defining and measuring these properties, which will be referred to as " combustion characteristics ". The burners most noticeably affected by changes in combustion characteristics are of the atmospheric or Bunsen type, covering, therefore, a very large proportion of the gas appliances in use today, both domestic and industrial.

It is nearly twenty years since The Institution of Gas Engineers through this Committee initiated an experimental enquiry into the relation between the composition of town gas and its efficiency in use, attention at the time being focused mainly upon the effects of variations in calorific value and inert constituents upon the behaviour of domestic cooking, heating and lighting appliances. This was followed by work upon the aeration of burners, which terminated for the time being in 1925.

Recently, this interest in the influence of gas quality on behaviour has been renewed, but since a considerable amount of work has been done on the subject in England, Germany and the United States of America within the past ten years, the Joint Research Committee decided that before resuming experimental work upon gas quality the now extensive literature of the subject should be thoroughly and critically examined, with special reference to the combustion characteristics mentioned above.

The Report now presented is largely a synopsis of the available information upon gas quality, combustion characteristics, and burner performance, and is intended to show which points may be regarded as definitely established, which require supplementary investigation, and to what extent gaps in our knowledge require to be filled.

The review may be divided into a number of well-marked sections, dealing respectively with rate of flame propagation in mixtures of gas and air, aeration of burners, design and use of test burners, and suggested criteria for representing the combustion characteristics of gases.

Rate of Flame Propagation

It is generally agreed that one of the most important factors governing the behaviour of a Bunsen burner is the rate of flame propagation in the primary air-gas mixture formed in the burner by injector action. In consequence, the rate of flame propagation in air-gas mixtures has been extensively studied, and data for the principal constituents of town gas have been obtained, as well as information relating to their binary and ternary mixtures. The results are summarized in graphical form for the commoner combustible gases. It is established that flame-speed is not a simple additive property, and the calculation of flame-speed curves for mixtures from data concerning their constituents does not appear possible, as yet, with the requisite degree of precision. When such information is required, experimental determinations must be made for specific mixtures, and the principal methods available for this purpose are reviewed. A brief description of the application of flame-speed curves to burner problems is given. The more important effects upon flame-speed of inerts, pressure, preheating, and radiation have also received attention.

Aeration of Burners

Since the air-gas mixture in burners is usually produced by injector action, attempts have naturally been made to ascertain the rules governing the process. Important contributions in this direction have been made by the American Bureau of Standards, while the Aeration Reports of this Committee, already mentioned, represent another attempt to deal with the subject. Attempts to calculate the degree of aeration from first principles, when given burner dimensions and the specific gravity and pressure of the gas, have proved disappointing, but some success has attended efforts to predict the changes in the air-gas ratio of specific burners for given changes in gas pressure, specific gravity or gas rate, after certain empirical constants have been determined. Typical aeration—gas rate curves have been determined for a number of burners, but it should be pointed out that the simple injector process is usually modified by heat conducted to the mixture passing through the burner body, and in the case of lighting burners, particularly, may be completely masked by " chimney " effects.

The production of stable flames demands amongst other things that the velocity of the air-gas mixture through the burner ports shall be suitably related to the flame-speed in the mixture. By making use of the aeration—gas rate curves for specific burners, and the corresponding aeration —flame-speed curves for the mixtures produced in them. one should be able to understand why a particular gas can or cannot be used successfully in a particular burner, and to suggest beneficial alterations in conditions of operation or design. Too little use seems to have been made of this approach to the subject, which follows fundamentals more closely than any other.

Test Burners

The desire to express the combustion characteristics of a gas by a single numerical value is natural, but may not be possible in a strict scientific sense because of the complexity of the phenomena involved. The method just described does not achieve this end, and the question arises if it would not be possible to utilize the behaviour of standardized Bunsen burners (in which changes in specific gravity, aeration and flame-speed would automatically exert their effects as in practice) for the purpose of defining gas quality; in other words, to produce a test burner for indicating combustion characteristics. The literature shows that several such burners have been devised, and descriptions of them and their principles of operation are given in the Report, including the burners of Hofsäss, Ott, Czakó and Schaack, and Watson House (Aeration Test Burner).

It is important to note that while considerable work has been done in developing these instruments, the practical problem of determining (i) the connexion between " Test Burner Number " and the corresponding behaviour of a gas in typical appliances, and (ii) the permissible range of gas qualities thus defined, which would be tolerated by any given appliance without the necessity for re-adjustment has, until recently, been almost neglected. Results communicated by Masterman and by Hawes, however, present quantitative information in this connexion, but are confined to gases of calorific value of 500 B.Th.U. per cu.ft. It is evident that the Committee has a wide field of work open to it in extending the investigation to gases of other qualities.

The survey of the literature upon test burners has been supplemented by a preliminary experimental examination of the Aeration Test Burner (A.T.B. No. A.124). The behaviour of this instrument towards pressure variation, the behaviour of representative gases over a C.V. range of 300 to 700 B.Th.U. per cu.ft., the relation between aeration, air-shutter opening and specific gravity of gas, and a number of miscellaneous points arising in its manipulation, are included. The Aeration Test Burner works most satisfactorily over the C.V. range 400 to 500 B.Th.U. per cu.ft., and the examination does not reveal any outstanding manner in which the design could be improved.

Calculation of Combustion Characteristics

The results obtained with test burners are expressed upon scales which are in all cases empirical, and attempts have been made from time to time to develop formulæ, criteria, or indexes of combustion characteristics which should have some fundamental basis and significance. The ideal formula would be one which would enable the combustion characteristics of a proposed gas mixture to be predicted without the need for resort to experimental determination. A number of these formulæ are examined in the Report. Some of them require a knowledge of the chemical composition of the gas, while others require a less detailed knowledge, and utilize the properties normally determined in Gas Works practice, such as calorific value and specific

gravity. The utilization of flame-speed curves and test burner numbers has also been proposed. Some of the suggested formulæ seem to be of service over a limited range of gas mixtures but, generally speaking, there are at present insufficient data respecting the properties of particular gas mixtures and their corresponding behaviour in gas appliances to enable a sound judgment to be expressed upon the reliability of such formulæ over a more extended field.

Discussion.

Dr. HAROLD HARTLEY: Under present conditions we have a wide variety of town gas supplies, differing in calorific value, pressure, density, and composition. Further, in any one area economic conditions may compel the maker of gas to alter three of these four characteristics. At the June Meeting, Mr. Stewart held out the hope that there might be effected a marked reduction in the number of different calorific values of supplies, but even if that desirable result were attained, there might still be marked differences in the properties of the gases of the same calorific value. In his Paper Mr. Stewart gave the composition of four gases each of a calorific value of 500 B.Th.U./cu.ft. which varied in density from 0·4 to 0·67. In this 40th Report Mr. Wood gives details of five gases ranging in calorific value from 396 to 560 B.Th.U./cu.ft. gross, and shows flame speed curves for three gases ranging from water gas to straight coal gas, which indicate the wide range of bunsen flame sizes that might be produced with gases covering a similar range of calorific value. These data indicate the possibility of wide variation of behaviour when used in appliances. Throughout the country the gas consumer is probably getting a result which falls far short of that which a domestic gas supply is capable of yielding. Not only is the adjustment of the appliance unsatisfactory in many cases, but the variation in the chemical and physical characteristics of the different gases supplied are such as make it difficult to ensure that any one type of apparatus shall be capable of yielding an equally good result everywhere. The density and pressure affect the mass of gas burnt and the primary air flow; the chemical composition of the gas and the primary air supply influence the size and shape of the flame, while the secondary air flow, which is generally determined by the design of the appliance, may not be satisfactory for all conditions.

Gases differing even relatively little in declared calorific value may give quite different combustion performances. This is exemplified by the following results attained in two of our laboratories with an experimental geyser. The experiments were made (A) in London, and (B) at one of our works.

Consumption. B.Th.U./Hr. Gross.	CO/CO_2 Ratio.	
	A.	B.
1	2	3
86,550	0·006	0·002
89,560	0·01	0·006
91,800	—	0·015

If this geyser had been rated on the works experience, the combustion results attained with it in London would have been unsatisfactory.

The need is obvious for full collaboration of technicians from the manufacture and supply sides of the Industry to try to define the degree of standardization necessary and the latitude for variation permissible both in the production of gas and in the apparatus in which it is to be used. An excerpt from the Presidential Address of the late Thomas Hawksley, quoted by Mr. Lacey, last June, seems apt—

"We can ascertain by research what are our deficiencies; we can ascertain by investigation the means for remedying these deficiencies."

How far then does the present communication go in the desired direction? Perhaps the outstanding impression produced is of the mass of experimental work already done, and the ingenuity exercised in an endeavour (*a*) to devise some formula that will define combustion characteristics, or (*b*) to construct a test burner which will indicate the behaviour of the gas supply in the appliances in use. In the summary, however, it is stated that ". . . the practical problem of determining (i) the connection between 'Test Burner Number' and the corresponding behaviour of a gas in typical appliances, and (ii) the permissible range of gas quality thus defined, which would be tolerated by any given appliance without the necessity for readjustment has, until recently, been almost neglected."

The principal use of Test Burners hitherto would appear to have been as means for indicating the lighting-back potentialities of gases. For this purpose might it not be advantageous to have such burners designed so as to yield information at the maximum flame speed attainable with the gas under examination? The characteristics of the inner cone of a bunsen flame are much influenced by the design of the burner itself, and this influence appears to be minimized when the mixture theoretically required for complete combustion is burnt. Such modification of design would at least make the flame more nearly characteristic of the gas itself.

There have been several attempts to define the conditions under which lighting-back is likely to occur in different types of apparatus. The differences in the experiences reported serve to emphasize the probability that the design of the burner in the appliance itself plays a predominant part. Perhaps in his section entitled "The Use of Flame Speed Curves," Mr. Wood might, with advantage, have included references to the experience of Smith and Pickering, to whose Paper on the Measurement of Flame Velocity he refers in a later section.

To me it seems doubtful whether any recording of a bunsen cone height for an arbitrarily chosen air/gas ratio or of an air/gas ratio which gives a particular cone height in a single test burner can provide an adequate measure of the influence of composition changes on the completeness or otherwise of the combustion attainable in apparatus in use on the district. Some months ago we made experiments with a loose boiling burner and kettle of water, working with gas obtained by enriching the main supply to No. 90 A.T.B. on the Watson House test burner. The enrichment was effected by introducing (1) CH_4, (2) C_2H_4, and (3) C_4H_{10}. The tests were made at "100 per cent. pressure overload" and the following results recorded:

SERIES I.—*Main Gas A.T.B. No.* 62.

Enriching Gas.	Gross Consumption. B.Th.U./Hr.	CO/CO_2 Ratio.	—
1	2	3	4
CH_4	12,115	0·007	Cones defined 25/32 in. No smothering.
C_2H_4	12,160	0·021	Cone tips 7/8 in. + ill defined with "Smothering" 7/8 in. +
C_4H_{10}	12,125	0·018	

SERIES II.—*Main Gas A.T.B. No.* 66.

CH_4	12,055	0·006	3/4 in.
C_4H_{10} .	12,161	0·016	7/8 in.

Also we measured the vertical heights of the inner cones of the bunsen type flames attained when metered mixtures of similar enriched gases and air were burned on a suitable teat of 11/32 in. diameter. The air/gas ratios were varied over the range 2·6 to 3·6, with the rate of flow of the combustible gas maintained at 4·5 cu.ft./hr.

At all aerations the ethylene-enriched gas gave cones shorter than those produced by the butane-enriched gas and as short as, or shorter than, those produced by the methane-enriched gas. Further, for the most part the butane-enriched gas burnt more slowly in the inner cone, at air ratios exceeding 3·4 the methane-enriched mixture gave the longest cones.

From these results it might have been anticipated that the ethylene-enriched gas would have given at least as good a combustion result as when the enrichment was done by methane. We had been desirous of using a readily available medium which would reduce flame speed with the minimum increase in calorific value, but although this was attained with butane, the effect on the CO/CO_2 ratio was much greater than that of methane, despite the fact that the latter had to be added in large quantities to attain the desired A.T.B. number. Roughly, the amounts of enriching gases used were

C_4H_{10}	1½ per cent.
C_2H_4	8 "
CH_4	28 "

It seems not impossible that the composition of the interconal gases and the secondary air requirements of flames produced at different degrees of primary aeration may have a direct influence on the combustion results attained with appliances using bunsen flames.

It would be helpful if some indication could be given of the extent of the variation in composition of typical town gas supplies which may have to be made for manufacturing reasons under present-day conditions, and especially if arrangements could be made for series of experiments to be carried out in selected works.

For the most part this 40th Report is concerned with the burning of gas in bunsen burners, but there is also

need for data on the behaviour of town gas burnt without pre-admixture of air. No doubt at a later date the advisability of exploring this aspect of the matter will be considered.

I wish to compliment Mr. Wood and Dr. Eastwood on the review they have produced of the existing literature. If anyone feels that too much, or too little, consideration has been given to particular aspects of the problem, I would remind them of the magnitude of the undertaking the authors of the Report had to face. There must have been many times during the past year when they have felt " . . . of making many books there is no end; and much study is a weariness of the flesh."

A Different Standpoint.

Dr. W. Payman: Naturally, I have been specially interested in the description of the work carried out by Professor Wheeler and myself on flame speeds, and I should like to say just a little about that. When we started our work on the flame speeds for mixed gases, in 1917, we made our experiments from quite a different standpoint. We were not interested in burning gases in industrial burners, but we were interested in explosions and safety from explosions, so that we made our experiments in tubes in which we could measure the travel of the flames. We were asked by our friends in the Gas Industry to try to apply our results to their particular problems, and in particular we were asked to give some indication of what happened in a burner if the composition of the gas were changed. We were asked to give general indications, to say something about the general characteristics of the gas, and I think that in a general way we were able to give the answers to the questions put to us. But since that time the Gas Industry has still been at work on the problem, and it wants a much more accurate measure of, say, the height of a bunsen cone or of the point at which the flame will flash up. The speed generalizations will not serve that purpose, because they are only meant to give general indications, the reason being that there are variations, as we know, from the speed generalizations, which assume a purely additive relationship between the speeds of different gases. As quite a rough approximation I believe that is the case. But if these simple calculations are to be applied to the problems of burning gas in burners, a fair amount more has to be done. First of all, we have to find out what these variations are and how they are caused; we have a rough idea as to how they are caused, and we have to measure their magnitude. Secondly, we must obtain more data, because when trying to apply our results to the problems of the Gas Industry we try to make quite a lot of estimates. We do need data, and it will have to be obtained, particularly with burners corresponding to those in use in the Industry, not by measuring the speeds at which flames move along a tube. Once we have the data for the gas burners we want to modify the generalizations to show such things as rates of chemical reaction, which depend on mass action factors and also upon specific factors such as the burning of carbon monoxide.

Dr. D. T. A. Townend: Apart from the practical aspects of the subject, particularly in regard to burner design and the physical disturbances associated with flowing *media*, I should like to direct attention to the great difficulty experienced when considering flame-speeds in the light of present-day knowledge of taking into account the possible part played by the various species concerned in the propagation of flame.

Thus we know from flame spectra that such radicals as OH, C_2, and CH are present and they give rise to an emission in the visible part of the spectrum. Bonhoeffer and Harteck have also shown by passing hydrocarbons into atomic hydrogen that the combined hydrogen atoms are successively removed with the formation of molecular hydrogen, the process giving rise to CH radicals and finally to C_2 radicals; both of these are easily excited, the CH emitting in the blue and the C_2 in the green region of the spectrum, just as they are found to do in flames.

There are doubtless other such species present in flames not sufficiently excited to reveal their identity, and processes unknown in ordinary chemistry are probably operative. While the Le Chatelier formula for the velocity of flame propagation, which is based on heat transfer from the burning to the unburnt medium, has served us well so far and is probably reasonably sound when considering flames of high energy content, it probably fails near the limits of inflammability where the life of reactive centres is more dependent upon circumstances of dilution and environment. And it is also almost certain that on like reasoning the burning of one combustible in a mixture will be affected by that of another.

As an example one may cite the complexity of the combustion of carbon monoxide which is well known, dual mechanisms for its combustion having long been recognized as the outcome of the researches of Bone and Weston. More recently the complexity of this combustion has been studied in the Leningrad laboratories, and in this country Garner has also recently proposed two mechanisms, that predominating at high pressures being determined by the rate at which hydrogen atoms are produced by collisions of newly formed CO_2 with H_2 molecules. The presence of such species also renders it necessary to take into account the existence of equilibria until recently not known; for example, $O + H_2 \rightleftharpoons OH + H$, $H + O_2 \rightleftharpoons OH + O$, $CO + OH \rightleftharpoons CO_2 + H$, etc.

There can be no doubt that the factors referred to all play a more or less important part in the flames concerned and contribute to the great difficulties generally experienced in standardizing the conditions for the combustion of town gas of varying composition in aerated burners.

Lighting-Back of Street Lamps.

Mr. F. O. Hawes (Tottenham): As mentioned in the Report, we have used at Tottenham a burner of the Ott type. For our particular purpose at the time, this was undoubtedly the correct choice. We were concerned with the problem of lighting-back of street lamps, and the obvious measuring instrument to use was one which indicated tendency to light back. Many criticisms have been levelled at the Ott burner, and it is quite true that it is not an instrument of such precision as the Prufbrenner or as the Aeration Test Burner. However, by individual calibration such as the A.T.B. itself demands, it can be made sufficiently correct for practical purposes. There is no point in having a scale of such fineness that it will indicate differences insignificant in practice, such as differences for ordinary changes in atmospheric conditions. There is some evidence that the Aeration Test Burner is open to these objections.

Please do not think that I am condemning the Aeration Test Burner. I feel that it is the best appliance so far put forward for testing combustion characteristics; but I also feel that we are not yet making the best use of it. We need to know something of the relation of its readings to the performance of appliances before we can say that the present scale is the most suitable.

On the matter of the variations of the Aeration Test Burner readings with atmospheric conditions, those who have been concerned with photometry will remember that elaborate tables were prepared for correcting photometer readings for the effects of humidity in the atmosphere; it is probable that the Aeration Test Burner is affected by this factor.

It is mentioned in the Report that a single figure to indicate combustion characteristic is what is required. Frankly, I think we shall waste time if we continue to seek for this. The flame speed curves of various air-gas mixtures are not parallel, and therefore no single figure can tell us all that we need to know of a gas. I suggest that there be at least two marks on the Aeration Test Burner mirror—say, at 14 mm. and 19 mm. If scale readings are taken for these two cone heights, the 19 mm. figure will give the ordinary A.T.B. number, while the difference between the two readings will indicate the increased aeration required to shorten the cone by 5 mm. We shall thus obtain some idea of the steepness of the flame speed curve. I have found gas mixtures of the same A.T.B. number but with flame speed curves of substantially different slopes. The significance of this is, of course, that of two gases of the same A.T.B. number, one might give a cone of satisfactory length in a particular appliance, while the other gave too long a cone. Conversely, the one might light back with a degree of aeration which could be tolerated by the other. Incidentally, that is one reason for my lingering fondness for the Ott burner. It does give a definite indication of at least one of the points of unsatisfactory performance, while the A.T.B. reading is, so to speak, in the middle of the scale and does not give any certain information about the regions on either side. I submit that the addition of a second reading at 14 mm. or some other point will be of considerable value.

There is one further important point which I wish to make. The present Aeration Test Burner has been designed for gas whose calorific value is 500 B.Th.U., and it may be necessary to have separate standards for gases of other calorific values—certainly when these are as low as 300 or as high as 560.

In our work at Tottenham we have found that a great deal of confusion is caused by using gases of varying calorific values, and I suggest that the experimental work of this investigation be done in stages, using one calorific value at a time. The procedure I have adopted is to have two test holders, one filled with gas of a given calorific value and with as high an Ott Number as possible, while the other contains carburetted water gas of the same calorific value. These gases can be mixed to give a wide

range of Ott Number at a fixed calorific value, and tolerance tests on appliances can be made under conditions which approximate to those on the district, where the calorific value is kept reasonably constant despite composition changes. The work may then be repeated with gases of other calorific values, and thus what may be termed the standard Ott Numbers for given calorific values are found, together with the permissible variations at these values. We shall then be in a position to investigate the changes in gas composition which gives these variations and thus relate our results to carbonizing practice. There is, of course, an immense field for study, especially when it is extended, as it must be, to cover the principles of design of appliances. Some may consider that the subject is not of sufficient moment to warrant the work and expense entailed. To these I would say that a very little experience of district difficulties where combustion quality variations are prevalent has led me to believe that satisfactory service in this direction is one of the points on which our Industry will stand or fall.

41st Report of the Joint Research Committee of the Institution and Leeds University

The Investigation of the Use of Oxygen and High Pressure in Gasification

Part II—Synthesis of Gaseous Hydrocarbons at High Pressure

Research Chemists: James W. Wood, M.Sc.Tech., A.I.C. ; F. J. Dent, B.Sc., Ph.D.

Research Assistants: W. H. Blackburn, M.Sc., Ph.D. ; A. H. Eastwood, B.Sc., Ph.D., A.I.C. ; H. C. Millett, B.Sc., Ph.D.

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General Introduction by the Livesey Professor, John W. Cobb, C.B.E., B.Sc., F.I.C.

On the side of gas manufacture the Committee has continued its work on the synthesis of gaseous hydrocarbons at High Pressure. Dr. Dent and his assistants have displayed a high degree of skill and resource in the design, erection and working of the special apparatus required, which has to withstand the combined effects for prolonged periods of high pressure and high temperature. We have to thank Marshalls, Sons and Company (Successors), Limited, Hadfields, Limited, and English Steel Corporation, Limited, for the assistance they have rendered us by the delivery of the special tubes required at a time when they were fully occupied with other and bigger work. The results obtained indicate the possibility of gasifying at these high pressures a large proportion of what has been regarded as the fixed carbon of coal, in the form of a gas rich in methane and of high calorific value. It appears that the gradual rise in temperature which at normal pressures would yield a comparatively small quantity of lean gas leaving the fixed carbon behind, will have other effects when the pressure is high. Then, in a stream of hydrogen, or gas rich in hydrogen, the fixed carbon comes away in quantity, mainly as methane, giving a much larger volume of much richer gas. This does not occur with a pure carbon such as graphite. It is presumably due to molecular instability facilitating chemical activity during the time when progressive molecular condensation is occurring as a consequence of rising temperature in the carbon-hydrogen complex, of which the coal at that period of its decomposition is mainly composed. The results are remarkable and are detailed below, and the possibilities they suggest are very alluring. The work is being continued on a large apparatus which, among other things, will permit the examination of the liquid products.

Dr. Key, who has completed for the time being his systematic work on effluents and ammonia, has been transferred to the staff on high pressure work at the University of Leeds, and has commenced an investigation into the influence of steam in high pressure gasification, a subject on which the published results are of a conflicting character, and insufficient for our purpose.

Statement by the Chairman of the Joint Research Committee, E. V. Evans, O.B.E., F.I.C.

In the general introduction to the 39th Report, reference was made to the altered character of our work on gas manufacturing processes and the reasons of the Committee for making the alteration were detailed at some length. In the past your Committee has confined its attention mainly to the examination of the chemical and physical aspects of processes already in operation. More recently we have felt that the Gas Industry possesses to-day chemists with a knowledge and experience enabling them to carry out such investigations, so that the study and development of processes already in operation may be safely left in their hands. Your Committee has been mindful of the valuable contribution which the Gas Industry makes to the welfare of the nation, but believes that with the accomplishment of so much, there remains still a great deal more to be done. We are confident that the nation will expect in the future a far greater contribution from the Industry entrusted with the treatment of its most valuable raw material, coal, and we believe that the most useful type of work that the Joint Research Committee can conduct is of the long range type having as its main object the cheapening of the cost of manufacturing gas and, at the same time, the development of means by which this greater contribution may be made.

The ultimate justification for having altered the nature of the work carried out under the direction of your Committee can only come at some time in the future, when the investigations at present in progress have borne fruit in the form of new or modified processes serving the needs of the Industry and the community more adequately than those which exist to-day; but in the account of work done, which forms the body of the Report, there can be found indications of some promise, and our goal seems measurably less visionary than it did a year ago. The experience of the gas and chemical industries in the treatment of coal has taught the important part played by hydrogen in influencing the decomposition of liquid and gaseous hydrocarbons. What we have not appreciated hitherto is the fact that, under pressures well above atmospheric, hydrogen can play a similar important and valuable part in influencing the mode of decomposition of the solid residue. The gasification of the solid residue in oxygen, in steam or in carbon dioxide is already practised in gas manufacturing processes, but the gasification of semi-coke in an atmosphere of hydrogen is a reaction which has not hitherto been applied for the production of town gas. It may be remarked that whereas we started this investigation by being interested primarily in the synthesis of methane from carbon monoxide and hydrogen, our immediate attention has now turned to the reaction between carbon and hydrogen. It is true that the newer reaction at the moment appears to hold the greater promise, but we are not losing sight of developments which may be possible through the medium of the reaction with which we were at first concerned. If there is one feature in this Report which is of greater interest than many others it is the versatility of hydrogen in reacting with the products of carbonization or partial carbonization of each of such a wide range of raw materials as lignite, non-coking coals, coking coals and semi-anthracites. The potential importance of this fact to the Gas Industry need not be stressed.

The Joint Committee on Complete Gasification, which was instituted in order to maintain a liaison between our investigations and those of the Fuel Research Board, has continued its work and has noted with interest the development at the Fuel Research Station of a modified method of operating normal water gas plant to permit the use of low volatile coal in place of coke. Under certain market conditions the ability to release an additional quantity of coke for sale may have considerable economic value.

SUMMARY

The experiments discussed in this Report continue the investigation of processes of gasification for the production of gas suitable for general distribution. The first part of the investigation, described in the 39th Report of the Joint Research Committee,* dealt with gasification in

* Inst. Gas Eng., Communication No. 141, 1936.

steam with oxygen and gave encouraging results. High thermal efficiencies of gas production were obtained without inconveniently high temperatures in the fuel bed, and the consumption of oxygen was considerably reduced by preheating the oxygen and steam supplies.

The experiments with oxygen were carried out at atmospheric pressure and, according mainly to the relative amounts of steam and oxygen supplied, the gas made consisted of varying proportions of hydrogen and carbon monoxide with some carbon dioxide. The results refer directly to the use of oxygen for the production of such gases, but they were primarily obtained for application to town gas manufacture with the view that gasification would be followed by a synthesis of gaseous hydrocarbons to yield a final gas of composition and calorific value more suitable for distribution. This Report is concerned with the synthesis of the hydrocarbons and especially with the possibility of promoting the synthesis by operating at high pressure.

The study of the production of gaseous hydrocarbons has been separated from that of the initial gasification to hydrogen and carbon monoxide although, in a process depending upon subsequent reactions at high pressure, it would probably be necessary to make the initial gasification under pressure in order to avoid compression charges. It may be that, in practice, the two stages would be best combined in the same fuel bed, as in the Lurgi process† which is operated with lignite in Germany. On the other hand, the separation of gasification and synthesis may be helpful in controlling the reactions involved and the products they yield and, in addition, may facilitate the use of the bituminous coals available in this country. In either case, for experimental purposes, it was deemed advisable to separate the two stages so that the investigation of the synthesis of hydrocarbons was not limited to the conditions of atmosphere and temperature in a bed of fuel being gasified with steam.

The first high pressure experiments were made, however, within conditions anticipated for a fuel bed undergoing gasification and were designed to see whether a synthesis of hydrocarbons could be expected to occur in the upper part of the bed to the same extent when using British coals as in the Lurgi process using lignite. Thus, a mixture of hydrogen, carbon monoxide, carbon dioxide and undecomposed steam, such as would be produced near the base of the fuel bed by the initial gasification reactions, was passed at 50 atmospheres pressure over various cokes heated to 800° C. The gas mixture was supplied at a rate equivalent to the gas output of a modern water gas plant and the cokes were made from lignite, semi-anthracite, and weakly caking and strongly caking coals. It was found that after treatment the gas had a considerable methane content which was not greatly dependent upon the type of coke so long as this had not suffered severe heat treatment during its preparation. In particular, the lignite coke did not appear to be specially favourable for methane formation.

The coals were converted to cokes before use in order to avoid any fusion of the charge in the reaction tube and consequent interference of gas flow. Methods for overcoming the difficulties likely to arise when gasifying caking fuels are receiving attention, but apart from these difficulties, the results of the preliminary experiments indicate that all types of bituminous coals, as well as lignite, can be gasified in steam under pressure with the synthesis of hydrocarbons in the fuel bed and the production of gas of a sufficiently high calorific value for general supply.

The investigation then entered a wider field. There were indications that most of the methane formed in the preliminary experiments was the product of direct combination of the coke with the hydrogen contained in the mixture of gases supplied and was not due to interaction of hydrogen and carbon monoxide. The hydrogenation of solid fuels to gaseous hydrocarbons plainly required a thorough investigation and the experiments described in the main part of the Report were made for that purpose.

The experimental procedure adopted was to heat various types of fuel to 800° C. in a stream of hydrogen, or gas containing hydrogen, at pressures between 1 and 100 atmospheres. The formation of gaseous hydrocarbons was observed during both the heating-up period and a period at 800° C. The fuels were also heated in nitrogen for comparative purposes. 1½ to 2¾ hours were taken in heating to 800° C. and this temperature was then maintained for a further 1½ hours. Results, obtained with a coke prepared at 450°-500° C. from a strongly caking Yorkshire coal, can be taken as typical.

When this coke was heated in nitrogen at atmospheric pressure it evolved hydrogen and methane along with smaller quantities of ethane, unsaturated hydrocarbons, carbon monoxide and carbon dioxide. The yields in hydrogen and methane were equivalent, respectively, to 23·0 therms and 14·7 therms per ton of coke, and the yield of total gaseous hydrocarbons to 16·3 therms.

When heated in hydrogen at atmospheric pressure the coke evolved less hydrogen and considerably more methane was obtained. Per ton of coke, there were only 1·3 therms in hydrogen but 33·8 therms in gaseous hydrocarbons. The greater yield of hydrocarbons was plainly the result of the coke being hydrogenated, even at atmospheric pressure, and up to 650° C. there was an absorption of the hydrogen supplied.

The most striking results were obtained, however, by heating the coke in hydrogen at pressures above atmospheric. Hydrogenation became much more pronounced and there were remarkably high yields of gaseous hydrocarbons. At 5 atmospheres the yield was equivalent to 92·1 therms per ton, at 10 atmospheres 132·9 therms, at 25 atmospheres 202·5 therms, at 50 atmospheres 276·0 therms and at 100 atmospheres 311·2 therms. Moreover, some methane was still being produced when the experiments were stopped, 1½ hours after attaining 800° C. At 50 and 100 atmospheres there was evidence of an increased yield of tar.

The outgoing gas was of high calorific value during the most active periods at the higher pressures. The maximum calorific values reached were, in B.Th.U. per cu.ft., 60° F. and 30 in. sat., 345 at 1 atmosphere, 429 at 5 atmospheres, 500 at 10 atmospheres, 589 at 25 atmospheres, 719 at 50 atmospheres, and 914 at 100 atmospheres. The calorific value of the gas obtained with a given pressure could be varied, however, by modification of the rate of heating the coke or of the rate at which hydrogen was supplied. Thus the gas had a higher calorific value when the rate of heating was increased or the rate of hydrogen supply reduced, although there was an accompanying decrease in the yield of hydrocarbons per ton.

When the coke was heated in hydrogen under pressure, the reactions resulted in a marked absorption of the hydrogen supplied. The absorption began with the appearance of methane at about 500° C. and continued until the end of the experiment. The therms in the hydrogen absorbed per ton of coke were 32·9 at 5 atmospheres, 60·8 at 10 atmospheres, 107·7 at 25 atmospheres, 153·5 at 50 atmospheres, and 193·5 at 100 atmospheres.

The potential heat in the hydrogen absorbed contributed only part of that in the hydrocarbons produced. The additional heat was derived from the coke and, at the higher pressures, a large proportion of the coke was gasified. The coke contained 19·8 per cent. of "volatile matter" when tested by the standard crucible method but, when treated with hydrogen up to 800° C., the percentage loss in weight was:—18·6 at 1 atmosphere, 27·7 at 5 atmospheres, 34·9 at 10 atmospheres, 44·6 at 25 atmospheres, 62·4 at 50 atmospheres, and 72·0 at 100 atmospheres.

When the coke was heated in hydrogen at the lower pressures, the hydrogenation reactions proceeded most rapidly at 500° to 550° C., the temperature range in which the coke decomposed with the evolution of methane when heated in nitrogen at atmospheric pressure. In hydrogen at higher pressures, the most rapid hydrogenation occurred at higher temperatures, viz., 700° to 750° C. This range is also related to the thermal decomposition of the coke, since it is at such temperatures that coke is known to undergo a profound change with the development of a denser carbon structure and, normally, a marked liberation of hydrogen. It seems clear that the hydrogenation of coke to gaseous hydrocarbons depends to a considerable extent upon the coke being thermally unstable at the temperature of treatment and that the main function of the hydrogen atmosphere is to modify the course of a decomposition which would in any case take place. Further evidence was obtained in support of this view.

Other fuels treated with hydrogen at high pressures were lignite, semi-anthracite, and cokes from a weakly caking coal. It is remarkable that, although there was some variation in the temperature at which hydrogenation commenced, the widely different types of fuel gave similar yields of gaseous hydrocarbons per ton. At 50 atmospheres the yield from lignite was no higher than that from the cokes of bituminous coals. With lignite, however, there was a lower proportion of residue, presumably due to its initially high content of "volatile matter".

The experimental data do not include information on the thermal efficiency of the production of gaseous hydrocarbons by the hydrogenation of solid fuels, but consideration of the nature of the reactions involved indicates that, if allowance is made for any tar, the potential heat in the hydrocarbons should be more than 90 per cent. of the potential heat in the hydrogen and fuel directly consumed in their formation.

Some experiments were made on heating coke in mixtures of hydrogen and carbon monoxide under pressure, since such mixtures can be manufactured more cheaply than hydrogen. It was found that as high a thermal

† 39th Report of the Joint Research Committee, *loc. cit.*

yield of gaseous hydrocarbons could be obtained with the mixtures as with hydrogen alone, if the rate of supply of the mixture and its pressure were increased so as to allow for the lower percentage of hydrogen in the gas supplied. While loss in the thermal yield was avoided by this procedure, dilution with carbon monoxide led to the gas being of lower calorific value.

Discussion.

Dr. J. G. KING (Fuel Research Station): The production of even one extra therm of gas per ton of coal has always been of importance to the Industry; how much more important is the discovery, in this research, of a means of gasifying a further 50 per cent. of the coke. The practical importance of the discovery and in what manner it shall best be utilized are still to be determined, and will involve such difficult questions as the relative importance of gas and coke markets, the supply of hydrogen, and the design of a large-scale plant to make the best use of the discovery. These considerations will have to be discussed in the future, but in the meantime we have before us the nucleus of a very interesting theoretical discussion.

The production of methane from coal and semi-coke is not, of course, entirely new, in view of the amount of work which has been done upon hydrogenation in connection with the production of oil. In experiments upon refractory coals such as fusain and anthracite at the Fuel Research Station, it has been shown that at 500° C. and a pressure of hydrogen of 200-250 atmos., quantities of methane can be produced which are equivalent to 76 therms in the case of fusain and 40 therms in the case of anthracite per ton of material. Similarly, Fischer and Frey (Brennstoff Chem., 1925, 6, 69) treated brown coal semi-coke prepared at 460° C. in the presence of hydrogen at 180-245 atmos. pressure. Without raising the temperature above 480° C. they produced 25 per cent. by weight of hydrocarbon gas equivalent to not less than 125 therms per ton.

Dr. Dent has amplified this finding by continuing the treatment of the semi-coke to a higher temperature, and has kept up his hydrogen concentration during the formation of hydrocarbons by using a flow method. In this way he has produced much greater quantities of methane. From the theoretical point of view it might have been interesting had he used a less thickness of fuel bed in order that the concentration of hydrogen should be kept up to the maximum throughout the whole thickness of the reacting coke. Dr. Dent has not considered it necessary to discuss the mechanism of the reactions which lead to the formation of hydrocarbon gases in this way. It would, I feel, have been of considerable theoretical interest had he sifted his experimental evidence to this end. I rather feel that it would have been more helpful had he presented his results entirely in units appropriate to a theoretical discussion, and reserved his calculations to such data as therms per ton of material to a separate section. I feel that such an arrangement would have made the situation clearer.

I have attempted to make some calculations as to the mode of attack of the hydrogen upon the semi-coke, but in the absence of complete analyses of the semi-coke used and of the final residues this cannot be done exactly. If one accepts that the semi-coke is a hydrocarbon, it is easy to conceive that interaction will take place on the surface between $-CH_3$ and $>CH_2$ radicals and adjacent hydrogen atoms. The calculations indicate that a high proportion of the hydrogen of the coke is combined as $\rightarrow$CH groupings; I think that Dr. Dent does not consider that combination of hydrogen can take place with pure carbon under the conditions of experiment. In the case of experiment 22, where as much as 311 therms of hydrocarbons were formed, my calculations indicate that a maximum of 430 therms could be available if all the hydrogen of the coke were combined in $\rightarrow$CH radicals. Dr. Dent probably has the exact data which are really required for such calculations, and I should be interested to hear in due course at what conclusion he arrives.

To continue the argument, it may be supposed that methane is formed from $-CH_3$ and hydrogen radicals in the same way during the carbonization of coal at atmospheric pressure, and that the hydrogen formed at higher temperatures is produced by the cracking of more resistant radicals such as $\rightarrow$CH. If this were so, then an increase of pressure of hydrogen must accelerate the first and retard the second reaction. This does seem to happen in fig. 1 (1 atmos. hydrogen), where the methane produced reaches a maximum at 520° C. and hydrogen production is retarded. As the hydrogen pressure is raised, methane formation will therefore increase as it does, but in fig. 5 we find that it seems to start more slowly (0·1 l. per hour at 640° C. against 0·1 l. at 600° in nitrogen). Can Dr. Dent explain this and also why, in this experiment, hydrogen is evolved at as low atemperatureas below 600° C.?

Finally, I have hesitated to discuss the practical application of Dr. Dent's discovery owing to the difficulty of deciding the best manner for its achievement. I do hope, however, that this has been considered by other people and that the discussion will continue on these lines.

May I make a brief reference to other work which we have been carrying out on the complete gasification of bituminous coal in water-gas plants. I have already reported (William Young Lecture) success with carbonaceous coals with 17 per cent. volatile matter. We have now, by using a recuperator to assist in the cracking of the tar vapours, succeeded in treating bituminous coals of 35-40 per cent. volatile matter without having any tar troubles. The most important property necessary in the coal is that it should be in lump form and have only sufficient caking index to avoid disintegration in the fuel bed and to cohere without forming large masses of coke. The yields which we have obtained with one not too suitable coal were 70,000 cu.ft. of water gas at 304 B.Th.U. (210 therms). We will almost certainly be able to report better results when we have completed our proposed experiments upon a coal having the optimum properties.

I have already reported the gasification of carbonaceous coals in a water gas plant. I am now able to report that we have succeeded, in introducing a cracking chamber into the system, in gasifying without any tar troubles whatsoever bituminous coals of from 35 to 40 per cent. volatile matter. We have obtained yields of over 70,000 cu.ft. of water gas, equal to 210 therms.

Self-Hydrogenation of Coal.

Mr. T. F. E. RHEAD (Birmingham): It is interesting to recall the work of Professor W. A. Bone and Dr. Coward at the latter end of last century in connection with establishing the synthesis of methane from carbon and hydrogen. I can well remember the controversy that was taking place in my student days. It is very pleasing to see that Dr. Coward is with us to-day; he must feel distinctly gratified to find that there are some practical applications arising from his work on the synthesis of methane. About three years ago Dr. F. S. Sinnatt read a Paper in Birmingham in which he referred to the distilling of coal in hydrogen, and that Paper rather led me to speculate on what I called then the self-hydrogenation of coal. In calculating how many therms were possible if all the hydrogen in the coal came off as hydrocarbons and did not come off as water or as free hydrogen, some fanciful speculations led one to believe that it might be possible to get over 300 therms, per ton of coal, of gas over 500 B.Th.U., including the water gas from the coke. If you take a hydrogen balance on ordinary high-temperature carbonization you will find that approximately equal quantities of hydrogen come off free and as methane. Could that hydrogen be obtained wholly as methane, we should thereby double the therms of methane produced. In translating the present work into practice, gas engineers are rather concerned about the high-pressure apparatus needed and the cost of compressing the gases. It has occurred to me that we have really got pressure for nothing. If we carbonized our coal in a suitably constructed heat-resisting steel retort and allowed the pressure to build up to the desired degree, should we not get self-hydrogenation? As regards the mechanism of the reactions, the chemists can speculate freely; but it is just possible that hydrogen has to be driven off the particular molecules with which it is united in the coal substance, and may have to re-unite with carbon in somewhat different form. Even with ordinary semi-vertical retorts, if we take a hydrogen balance we nearly always find a shortage of hydrogen. It has gone into the hydrogenation process.

Mr. T. CAMPBELL FINLAYSON (Woodall-Duckham Companies): This work brings into prominence a fact which cannot be too clearly remembered by all of us engaged in the processing of coal—namely, that coal is not a mass of fixed carbon associated with what is termed "volatile matter," but *is* fundamentally a carbon hydrogen complex. Processes such as coal carbonization, as well as these newer fields of coal hydrogenation, are more easily understood and more hopefully explored if we keep this fact in mind. Secondly, it is a fact of very considerable importance that the present investigation has shown that the *source* of the coke to be subjected to hydrogenation was of no great significance provided that it had not been heated above a certain temperature. We might quite reasonably have assumed that only a few cokes of special reactivity would respond to this treatment. To find that such widely different fuels as lignite, bituminous coals, and semi-anthracite all give similar results is as remarkable as it is important. It obviously implies that

this new technique, if ultimately it can be developed on a commercially sound basis, will be applicable on a wide variety of fuels.

The point I particularly wish to discuss, however, is the composition of the gas by which the hydrogenation of the coal is brought about. As the present work is the second stage of the investigation on the gasification of fuel by oxygen under pressure, it is natural that some of the hydrogenation tests should have been carried out with a mixture of hydrogen, carbon monoxide, and nitrogen in the proportions likely to be found in complete gasification gas—especially as the first idea was that hydrocarbons might be formed directly by the synthesis of carbon monoxide and hydrogen. The main work, however, has been done using hydrogen, although the effect of mixtures of hydrogen and carbon monoxide have also been studied latterly. It is shown in the report that the admixture of carbon monoxide with hydrogen is definitely disadvantageous, involving the use of higher pressures and the production of lower calorific value gas, these effects being more serious as the percentage of carbon monoxide increases.

It may be worth while calling to mind that other industries have found the need for a gas consisting predominantly of hydrogen and that many millions of cu.ft. of gas are made per day containing over 85 per cent. hydrogen. Whether or not this is a cheaper gas in comparison with a gas richer in carbon monoxide for operating the type of hydrogenation process outlined in the present report ultimately turns on yield and quality of the final product. May it not, therefore, be well to keep in mind that in the production of the final enriched gas ready for distribution there are two avenues of approach each of which use the same ingredients—air, water, and coal. The first avenue depends upon the compression of a large volume of air in order that one-fifth of the volume—the oxygen—may be made available for gasification of the coal under pressure, followed by the hydrogenation of the coal by the mixture of hydrogen and carbon monoxide to produce the final gas for distribution.

The second avenue depends upon the complete gasification of coal at atmospheric pressure in either a one-stage or a two-stage process, using the necessary oxygen from the air without any power or capital cost; this would be followed by the conversion of water gas by the Standard Process to a gas largely composed of hydrogen, compression of this hydrogen, and, finally, hydrogenation of coal by means of this gas with the formation of a final gas rich in hydrocarbons and hydrogen and low in carbon monoxide. No doubt the Investigation Committee have this alternative avenue in mind and will consider the overall costs. From the technical viewpoint there is no difficulty in producing gas for hydrogenation purposes in which hydrogen is the predominant constituent.

The final point I wish to make is this. In the experimental work covered by this Report we find frequent mention of straightforward hydrogen "H_2". One has a faint idea that other workers have found the importance of hydrogen in the less simple condition which is termed "*nascent*." Is it intended to explore the influence of nascent hydrogen in the fascinating reactions described in the Report, or is this a complication which can be ignored?

Removal of Sulphur Compounds from Gas

Papers by H. HOLLINGS, M.Sc., W. K. HUTCHISON, B.A., and R. H. GRIFFITH, D.Phil.,

of the Gas Light and Coke Company

Communication No. 175

I.—Mr. Hollings' Paper.

I REMOVAL OF SULPHUR COMPOUNDS FROM GAS

For some years the Gas Light and Coke Company has been steadily extending the practice of recovering benzole from gas, and one of the considerations which has influenced this policy has been the circumstance that sulphur compounds such as thiophen and carbon disulphide are removed to some extent simultaneously with the benzole.

Processes

The sulphur compounds are removed by physical processes of adsorption by active carbon or absorption by wash oil.

Active Carbon Process

It is now well known that in the active carbon process about 75 per cent. of the total sulphur compounds are removed. This process has been described on previous occasions* and the commercial success of the process is indicated by the erection by the Gas Light and Coke Company of a third plant at their Bromley-by-Bow Works.

Normal Oil Washing Process

Only about half the above quantity of sulphur is removed in the normal oil washing process, and much thought has been given to the possibility of modifying existing oil washing plants in view of the high capital expenditure which would have been involved in replacing them by carbon plants. The outcome of this intensive study of the oil absorption process is the Kensal Green plant described by W. K. Hutchison in a later Paper.

In studying the removal of sulphur compounds by these physical processes we have regarded it as necessary to remove at least about 80 per cent. of the benzole simultaneously. Alternative processes designed to leave the benzole in the gas (or to return it) appear to involve a prohibitive charge for steam except under the special local circumstances of certain relatively small Works and except when using a chemical treatment of the oil as described below.

Objection may be taken to this dependence of sulphur extraction upon benzole recovery, particularly in the case of an Undertaking having a high declared calorific value or in the case of any Works equipped with vertical retorts in which heavy steaming of the charge has represented normal practice. The recovery of 100 gal. of benzole may mean that a market must be found for three more tons of coke. This is hardly a suitable occasion for a discussion of the economics of making gas of different calorific values in vertical retorts, but it may be noted that in several recent installations of new and reconstructed continuous vertical retorts the Gas Light and Coke Company has required modifications in design to permit of making a purified gas having a calorific value of about 540 B.Th.U. The purpose of this is to maintain a calorific value of about 510 B.Th.U. in the coal gas after extraction of benzole and sulphur compounds.

A further incentive to find a gas purification process independent of benzole extraction is the possibility of producing a sulphur-free crude benzole.

In the course of a laboratory survey several chemical as distinct from physical processes were examined. A common difficulty which is encountered is the presence of carbon dioxide in much greater concentration than carbon disulphide in gas.

Oil Washing Process (B.P. 452,167)

In one process developed in the laboratory (B.P. 452,167) gas is washed with a relatively large volume of oil in order to remove carbon disulphide from the gas. The oil is then regenerated by treating it with a solution of alcoholic caustic soda. As a preliminary step, however, it is necessary to remove the carbon dioxide which is dissolved in the oil in order to avoid an excessive loss of the alcoholic caustic soda.

The carbon dioxide is extracted by using a solution of potassium carbonate. This reagent in turn is regenerated by heat, carbon dioxide being expelled from the acid potassium carbonate solution by a well-established method.

In the reaction with the alcoholic caustic soda, sodium xanthate solution is formed. Carbon disulphide and methanol are recovered from this solution by acidification and distillation. The methanol is used again to prepare a fresh solution of caustic soda.

In this process carbon disulphide is removed from the gas without any substantial removal of benzole as the

* H. Hollings and S. Hay, Chemistry and Industry, 1934, 143; H. Griffiths, J. Inst. Fuel, 1935, **8**, 277.

wash oil becomes saturated with hydrocarbons. It appears, however, that the process would be rather expensive in large scale operation and that there might be difficulty in avoiding the formation of unpleasant by-products. For the time being development work in this direction has been suspended. This decision was influenced by the development of a new catalytic process which appeared to be capable of removing a greater proportion of the total sulphur in the gas at a lower cost.

Catalytic Process

An intensive study of catalysts for use in various gas reactions has been made in the Fulham Laboratory over a period of seven years. This developed originally out of our work upon hydrogenation catalysts, and at the time the survey of sulphur purification processes was in hand, a study was being made of the catalytic treatment of coal gas with the particular object of removing nitric oxide. As described in a later Paper by R. H. Griffith, it was discovered that at a moderate temperature of about 250° C. carbon disulphide could be preferentially and continuously oxidized to sulphur dioxide and so easily removed from the gas.

Costs

It is often asked what is the cost of removing the organic sulphur compounds from gas. So far as this new catalytic process is concerned no data can be given until the working results of the plant now in course of erection at Harrow are known.

In connexion with the well-known process* of the South Metropolitan Gas Company, in which carbon disulphide is converted to hydrogen sulphide at a temperature of 300°-400° C. with periodic aeration of the catalyst, the total cost of fuel, wages, power, repairs, and maintenance amounts to 0·0779d. per therm.

In connexion with processes whereby sulphur is removed along with the benzole, a first approximation of the cost, which may properly be regarded as a gas purification charge in respect of the removal of the organic sulphur compounds from the gas, may be obtained by considering the depreciation of the benzole resulting from the presence of sulphur in it. According to one basis upon which benzole may be evaluated, the value of crude benzole containing 1·5 per cent. by weight of sulphur, such as is often obtained when the sulphur content of the gas is reduced below 10 gr. per 100 cu.ft., is 1·3d. per gal. less than the value of crude benzole containing under 0·5 per cent. of sulphur. This value change is approximate and based on current values. It is due to the increased cost of refining the crude spirit, and it represents a loss of about 4d. per ton of coal or a charge in respect of sulphur purification of about 0·05d. per therm of gas treated.

The value of crude benzole containing 1·5 per cent. of sulphur, such as is obtained in the Kensal Green plant is, however, only about 0·65d. per gal. less than the value of crude benzole obtained in a normal oil washing plant, so that the cost of reducing the sulphur content to about 8 gr. per 100 cu.ft. instead of down to about 25 gr. per 100 cu.ft., as in the ordinary oil washing process, is only about 2d. per ton of coal or, say, 0·025d. per therm of gas treated.

In connexion with these costs based upon the evaluation of crude benzole, it is important to notice that at certain large Works the extra cost of refining benzole of high sulphur content is considerably less than assumed above, in which case the cost of removing sulphur simultaneously with benzole will be correspondingly reduced.

Conclusion

In conclusion it may be noted that during recent years the successful large scale removal of sulphur from gas has been dependent upon, and in no small measure incidental to, the removal of benzole from gas. When the active carbon process was introduced it represented a striking advance in the technique of benzole extraction quite independently of the circumstance that so much of the sulphur was removed from the gas. More recently the thermal efficiency of the oil washing process has been improved by the adoption of improved heat exchange auxiliary plant and, at the same time, the advantage of distillation under reduced pressure has been realized. These advantages in the oil washing process may be applied to the recovery of benzole quite independently of sulphur removal. It appears desirable, therefore, that at an early date we should consider the merits of the catalytic purification of gas as a preliminary to the oil washing process as well as a preliminary to the carbon process, as it is at Harrow.

* Inst. Gas Eng. Communication No. 146 (1936).

2.—Mr. Hutchison's Paper.

II A PLANT FOR THE REMOVAL OF SULPHUR COMPOUNDS BY OIL WASHING

A preliminary examination of the possibility of removing sulphur compounds was begun in 1927 and the results of this were described by Hollings and Hay.[1] The theoretical treatment followed from a simplified application of Raoult's Law to a counter-current washing operation, in which a number of solutes might be absorbed simultaneously. It was suggested that the quantity of solvent required to wash a given solute from the gas would be proportional to the vapour pressure of that solute in the pure liquid form. Since the vapour pressure of carbon disulphide is four times as great as that of benzene at the normal washing temperature, the quantity of wash oil required should be four times as great as that required for complete extraction of benzole. Conversely, in a normal benzole plant the quantity of oil used is only sufficient to remove about one quarter of the carbon disulphide in the gas.

The investigations of the Gas Light and Coke Company were resumed some years later when a standard of comparison had been set up by the successful performance of benzole plants of the active carbon type, capable of treating a total of 77 mill. cu.ft. of gas per day. It was concluded that a plant of the oil washing type could be constructed, of which the first cost and running costs would compare not unfavourably with existing benzole plant. In particular, it was anticipated that by the modifications in the normal technique which it was proposed to adopt, principally the method of distilling under a partial vacuum at the relatively low temperature of 170° F., the steam consumption would be little, if at all, higher. (B.P. 443,094.)

One object which was particularly in view in reconsidering the oil washing process at this time was the possibility of being able to convert some of the several oil washing plants which were working throughout this Company, but when finally it was decided to proceed with the new process it was found that for a first plant there was much to be said for building entirely from the ground. By this procedure it was possible to avoid any interruption of benzole production during the building period, and it was decided to apply the process at the Kensal Green Works, where there was no benzole plant. The plant, which is illustrated in Figure 1, was designed for 7 mill. cu.ft. of coal gas per day, the gas being a mixture of approximately two-thirds from vertical retorts and one-third from inclined retorts.

The building of a plant of this size without experience with a pilot plant is unorthodox and may provoke some criticism. It should be pointed out, however, that on the heat exchange side the component parts had been used on the same scale in other plants, and it was felt that the very straightforward nature of the oil washing process made it possible to calculate and predict the behaviour of almost every unit with accuracy, particularly in view of the great quantity of work which has been done on heat transfer to fluids, and the useful correlations which are available.

On the mechanical side, the use of centrifugal pumps was obvious in view of the large quantities of oil to be dealt with, and the selection of geared de Laval turbines to drive the pumps was decided on grounds of reliability, steam economy, and the production of an oil-free exhaust steam suitable for heating purposes. Both types of plant had been extensively used in the Works of the Gas Light and Coke Company for other duties, which gave a good measure of their reliability and performance. The vacuum-producing system required very careful consideration, and in the end it was decided to instal a wet vacuum pump with a steam jet ejector as an alternative.

In the remaining section of the work consisting of the mass transfer plant, *i.e.*, the gas washers and the still, several departures from normal gas works practice were indicated by the nature of the problems involved. Owing to the high rate of oil flow it was decided to wash the gas in tower scrubbers with board packing, the dimensions of which were based on experimental investigations of the specific rates of absorption of carbon disulphide by oils. The still chosen was of the Badger High Efficiency type specially designed for working under the conditions of reduced pressure and high oil rate which the process demanded.

The plant was completed on the 9th February of this year, much of the preliminary tuning up of oil circuits and mechanical performance being carried out during the later stages of building. It was put to work on the following day and has remained on continuous full production up

[1] Chemistry and Industry, 1934, 143.

to the present date, and apart from a few minor adjustments, chiefly of a mechanical nature, and the addition of a further source of cooling water to be used under extreme summer conditions, it has not required any modifications or alterations. Practically all the results calculated for the design data have been obtained or exceeded, and methods have been indicated whereby in a future plant useful economies will be effected both in the size of plant and in the cost of operation.

The oil used throughout in the Kensal Green plant has been ordinary gas oil, and during nine months' working there has been no replacement except for make up of losses, and no troubles due to sludge have been experienced. This must be attributed to the low stripping temperature, and perhaps in some degree to the high oil velocity used in the heaters.

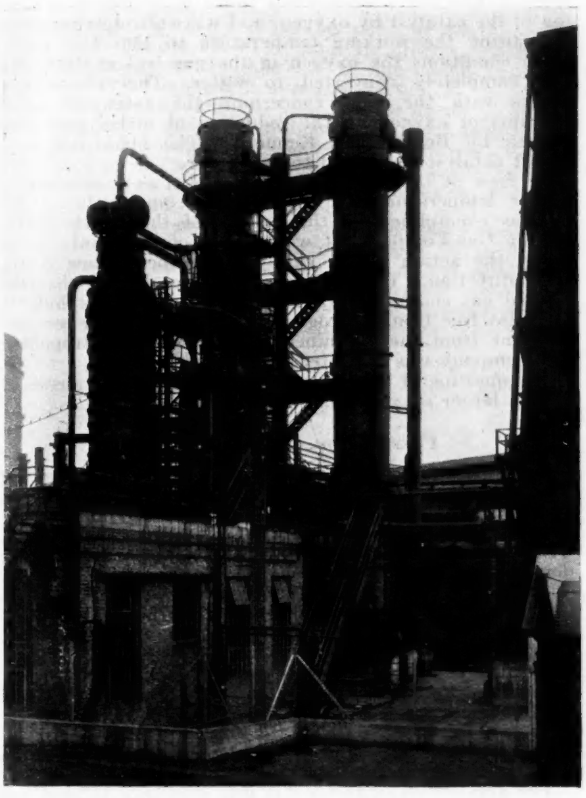


FIGURE 1.—*Plant for the Removal of Sulphur Compounds by Oil Washing at the Kensal Green Works of the Gas Light and Coke Company.*

The present process differs from existing processes of benzole recovery in the much larger quantity of oil to be circulated and the lower ratio of steam to oil required in the stripping operation. Conditions which experience and custom have dictated for benzole plants were not necessarily those which would give the most economical operation now. A fresh examination was therefore made of the heat required in each part of the process, the steam required for stripping, and the steam equivalent of the power used, in relation to the temperature of distillation and the arrangement and efficiency of heat exchangers.

It was concluded that for the particular operation of removing carbon disulphide from oil the most favourable stripping temperature was below 100° C., and involved the use of reduced pressure. A further examination of the whole question was then made, introducing the step of vacuum distillation, with due consideration paid to the extra power required for the production of the vacuum. It then appeared that the most favourable conditions would be found in a distillation temperature of 80° C. at 200 mm. absolute pressure. Operating in this way under vacuum and at temperatures well below 100° C. has the additional advantage that for heating the oil and for stripping it in the still, exhaust steam at atmospheric pressure can be used efficiently and in plants of reasonable size.

RESULTS

As stated, the plant has been at work continuously on full load since it was started in February, apart from a few short periods for minor alterations. Supervision is maintained by one operator on each shift, and a system of recording flow meters on steam and oil and of recording thermometers and pressure gauges provides an accurate record of the working conditions. The gas rate has been nearly constant throughout, but in order to maintain the maximum economy in operation adjustments of oil rate are made from time to time following variations in the oil temperature with changes in atmospheric conditions.

Efficiency of Sulphur Removal

The monthly efficiencies of sulphur removal shown in Table 1 are based on averages of continuous observations covering the whole period under review.

TABLE 1.—*Sulphur Removal*

Month	February.	March.	April.	May.	June.	July.	August.
1	2	3	4	5	6	7	8
Sulphur at inlet, gr. per 100 cu.ft. ..	34·4	35·7	32·9	33·0	32·1	32·1	33·9
Sulphur at outlet, gr. per 100 cu.ft. ..	9·4	10·0	10·3	9·5	10·0	9·7	8·3
Sulphur removed, per cent.	73	72	69	71	69	70	76

The proportions of different sulphur compounds in the gas entering and leaving the plant were determined, and some representative figures are given in Table 2.

TABLE 2. - *Removal of the Different Sulphur Compounds*

	Gas Entering Plant.			Gas Leaving.	Per Cent. Removed.
	Vertical.	Inclined.	Mixed.		
1	2	3	4	5	6
Mercaptan	2·2	1·1	1·8	0·5	70
Thiophen	5·0	8·3	6·1	0·8	87
Carbon disulphide ..	19·6	16·9	18·7	1·9	90
Volatile sulphur compounds	5·6	4·9	5·4	5·4	Nil
Total	32·4	31·2	32·0	8·6	73

Benzole Recovery

The benzole made from a mixture of two-thirds gas from vertical retorts and one-third gas from inclined retorts has averaged 3·7 gal. per ton of coal representing some 84 per cent. of the benzole in the gas.

The following is a typical analysis:

Specific gravity	0·837
„ „ once run	0·844
Fraction to 100° C.	72·5 per cent.
„ „ 160° C.	91·0 „
Sulphur	1·4 „

The sulphur in the benzole agrees closely with that removed from the gas as shown by a balance obtained over a period of thirty days.

Sulphur at inlet of plant, 201 mill. cu.ft. at 32·7 gr. per 100 cu.ft. ..	9,390 lb.
„ „ outlet „ „ 199 „ „ „ 10·1 „ „ „ ..	2,870 „
Sulphur removed from gas	6,520 „
Sulphur in benzole 54,360 gal. sp.gr. 0·837 at 1·4 per cent. sulphur	6,400 „

No fresh oil is added apart from that required to make up losses which average 2·5 per cent. of the benzole produced, the naphtha fraction being returned to the oil in circulation. Naphthalene is removed so completely from the gas as to make its determination by the picric acid method impossible in the outlet gas.

Steam Consumption

Table 3 shows the principal operating data for each month, including the steam consumption per gal. of benzole made. This figure covers all steam used in the process, including water pumping and benzole loading.

The increase in steam consumption during the summer months is due in part to the higher oil circulation which the rising oil temperature demands. The figure for August is exceptional in that the deficiency in the existing water cooling plant made it necessary to bring into use the additional water pumping set, so that a certain proportion of surplus steam was being blown off. Representative

TABLE 3.—*Benzole Recovery and Steam Consumption*

Month	February.	March.	April.	May.	June.	July.	August.
1	2	3	4	5	6	7	8
Gas washed, mill. cu.ft.	123	201	199	205	199	208	196
Average oil rate, gal. per hr.	8,200	7,900	8,800	9,000	9,000	9,200	9,500
Benzole recovered, gal.	38,167	53,985	54,630	57,230	54,400	57,573	53,565
Wash-oil loss, per cent. of benzole	5·7	4·8	3·3	1·4	1·9	3·3	2·7
Benzole made, gal.	36,000	51,400	52,800	56,400	53,400	55,600	52,200
Benzole made, gal. per ton of coal	3·69	3·51	3·59	3·74	3·70	3·70	3·70
Steam consumption, units	150	208	205	211	220	250	264
Steam consumption, lb. per gal. of benzole	39·4	38·5	37·5	36·9	40·5	43·5	49·3

balances of steam used and heat recovered under more normal conditions are given in Table 4.

TABLE 4.—*Steam Used and Heat Recovered*

Gas rate .. 285,000 cu.ft. per hr.
Oil rate .. 9,000 gal. per hr.
Benzole make .. 73 gal. per hr.

	Vacuum Pump.	Steam Jet.
1	2	3
Steam for oil and water pumps (90 lb. per sq.in.)	2,270 lb. per hr.	2,270 lb. per hr.
Steam for vacuum pump	200	—
Total steam for power	2,470	2,270
Losses	370	370
Exhaust steam available (5 lb. per sq.in.)	2,100	1,900
To still	1,230	1,150
Available for heating	870	750
Make up	450	−110 (surplus)
Steam for heating oil	1,320	640
Steam equivalent of heat:—		
Recovered from steam jet	—	650
,, ,, vapours	570	510
,, ,, hot oil	1,900	1,900
	3,790	3,700

CONCLUSIONS

The introduction of the vacuum method of distillation has not been accompanied by any special difficulties in operation of the plant, and there seems to be no reason why in smaller units semi-automatic control, as used in benzole plants of orthodox design, should not be employed. Experience gained in the design and operation of this plant has suggested a few simplifications and improvements. A single tower scrubber, more closely packed, could take the place of the two scrubbers now used, and the flow through the heat exchangers should be arranged to allow more accurate control of benzole quality without sacrifice of heat recovery. Finally, a more efficient method of water-cooling is necessary with a plant on full or nearly full load during the summer months. In the absence of a reliable natural source, a forced draught cooling tower—the fan driven by a steam engine exhausting into the low pressure system—would give a satisfactorily cooled water at no extra cost for power, the only charge for water being the make-up of 3·4 gal. per gal. of benzole recovered.

It is considered that with these modifications a fair estimate of the steam consumption would be 34 lb. in winter and 40 lb. in summer per gal. of benzole recovered, when recovering 3·7 gal. per ton of coal or 2·7 gal. per 10,000 cu.ft. of gas and recovering 75 per cent. of the sulphur from vertical gas or a rather higher proportion from gas from horizontal retorts.

3.—Mr. Griffith's Paper.

III CATALYTIC REMOVAL OF SULPHUR COMPOUNDS

INTRODUCTION

In a Paper to the Institution last year, H. Hollings pointed out that the formation of nitrogenous gum in coal gas was due to the presence of very small quantities of nitric oxide which reacted with diolefine hydrocarbons. During a search for methods of removing this substance, attention was given to the possibility of a catalytic process for its decomposition and a survey of the contact materials available for this purpose was completed early in 1936. It was found that catalysts prepared from nickel and cobalt compounds were particularly effective.

At a working temperature of 100° C., with a nickel catalyst, the removal of nitric oxide was found to be complete with space velocities over the catalyst of the order of 1,500 volumes per hour, but the activity slowly decreased until it had practically disappeared after a few weeks. This deterioration was found to be due to poisoning of the catalyst by oxygen, and was entirely eliminated by raising the working temperature to 150° C. Under these conditions the oxygen in the gas was continuously and completely converted to water. This observation agrees with the facts concerning the action of small amounts of oxygen on the reduction of nickel oxide described by Benton and Emmett.* The behaviour of a cobalt catalyst was found to be similar.

In view of the known effect of nickel as a catalyst at higher temperatures on the sulphur compounds in coal gas, as exemplified by the process of the South Metropolitan Gas Company, it was clearly of great interest to study the action of the catalyst described below in the same direction. Tests on a small scale showed that the treated gas contained practically no carbon disulphide; it was also free from hydrogen sulphide, so that a reaction different from that obtained by the South Metropolitan Gas Company was indicated.

The question of the fate of the sulphur was not answered until a larger catalyst unit was put to work.

PREPARATION OF THE CATALYST

The production of the contact material to fill a reaction space of 1 cu.ft. was then undertaken, and involved the selection of a carrier on which the nickel could be deposited. Ordinary brick or firebrick supports and charcoal were found to be quite unsatisfactory as they all led to the deposition of gummy products and rapid loss of activity. It is evident that the interaction of nitric oxide with hydrocarbons, or the polymerization of the hydrocarbons alone, was catalysed by these support materials quite apart from any effect of the nickel or cobalt.

A white china clay was eventually found which did not suffer from this disadvantage, and it is probable that iron and titanium compounds in other clays lead to the undesirable effects noted above; the fouling of active charcoals by reactions of this type is, of course, well known from experience in benzole recovery.

The application of the nickel was then investigated and it was found that direct production from nickel chloride solution was not successful as the resulting catalyst was very inferior to that obtained from nickel hydroxide. Deposition of an active nickel hydroxide skin on pieces of porous china clay was eventually achieved by soaking in a boiling solution of nickel chloride, draining off the superfluous liquid, drying the clay pellets at 100° C. and plunging them into an excess of alkali. (The various stages of preparation are illustrated by samples.) After the product had been washed free from chloride it was activated by treatment with coal gas at 350° C. for two hours.

APPARATUS.

The lay-out of the 30,000 cu.ft. per day unit is shown in the diagram. Gas from the purifiers passes through 4 runs of 2 in. pipe contained in a jacket 10 in. in diameter and is heated to 150° C. by saturated steam at a pressure of 100 lb. per sq.in. The electric heater, made from 2 in. pipe wound with resistance wire, raises its temperature to 160° to 180° C., at which temperature it enters the catalyst bed through a distributor. After passing through the catalyst bed, the gas leaves the plant through a water jacketed cooler and separator.

The catalyst bed is 22 in. in height and is contained in a lagged cylindrical vessel made from 10 in. steam main. The catalyst is carried on a circular table 4 in. above the bottom cover and fills the vessel to within 4 in. of the top. Normally the whole of the gas is heated, but the catalyst temperature can, if necessary, be rapidly reduced by diverting the inlet gas through the by-pass.

Temperature control is effected by thermocouples at the outlets of the preheater and the electric heater and by four radial couples, as shown, in the catalyst bed. Gas flow is controlled by a 2 in. gate valve on the outlet line and is measured by an orifice plate installation. Gas sampling points are provided on the inlet and outlet sides of the

* J. Amer. Chem. Soc., 1926, **48**, 632.

plant, and a continuous record of the oxygen content of the inlet gas is kept.

The catalyst was reduced and activated in batches in a resistance furnace 2 in. in diameter. This was so arranged that the catalyst occupied only the constant temperature zone of the furnace and could be discharged into the catalyst vessel without contact with air after treatment.

Results

Purified coal gas was passed through the catalyst bed at about 1,500 vol. per hr. per unit vol. of catalyst space, with an inlet temperature of 160° to 180° C. This rate may be compared with those employed in the normal iron oxide purifiers, where 2 to 4 vol. per hr. per unit vol. of oxide are generally employed. The catalytic process, therefore, required approximately 1/500th of the cubic capacity necessary for normal purification.

The experimental unit has now run for nearly 40 weeks and has treated about 10 mill. cu.ft. without renewal or alteration of the catalyst. The removal of nitric oxide is still complete as far as tests with the usual Griess reagent are concerned, so that there is probably less than one part in several hundred million parts of gas.

The fate of the sulphur compounds was more easily investigated on the large unit, partly owing to the relatively smaller mass of nickel and partly owing to the possibility of several simultaneous tests being carried out. The catalyst was largely converted to nickel sulphide, which is actually the active contact agent. It will be recalled that the catalyst described by Evans and Stanier* was also found to be nickel sulphide. Oxygen again disappeared completely and the heat evolved by its combustion led to a steady rise in temperature throughout the catalyst.

Catalytic combustion was also found to be responsible for the disappearance of carbon disulphide, which was converted to carbon dioxide and sulphur dioxide, as well as small proportions of sulphur trioxide. If the temperature rose too high a back reaction set in and hydrogen sulphide was produced by catalytic hydrogenation of sulphur dioxide.

It is at first rather surprising to find an oxidation process going on in contact with a catalyst which is also accelerating a hydrogenation reaction, particularly in view of the relatively great excess of hydrogen in the gas mixture. Modern knowledge of the principles underlying catalytic processes, however, has shown that an active surface may affect the velocity of several reactions occurring side by side, and from the purely chemical features of this conversion of carbon disulphide there is nothing abnormal to be found.

Calculation of the thermal effects involved in the alternative reactions of carbon disulphide or carbon oxysulphide with hydrogen and with oxygen gives the following results:—

$$CS_2 + 4H_2 \rightarrow CH_4 + 2H_2S + 50{\cdot}8 \text{ k.cals.}$$
$$COS + 4H_2 \rightarrow CH_4 + H_2O + H_2S + 46{\cdot}3 \text{ k.cals.}$$
$$CS_2 + 3O_2 \rightarrow CO_2 + 2SO_2 + 258{\cdot}3 \text{ k.cals.}$$
$$COS + 1\tfrac{1}{2}O_2 \rightarrow CO_2 + SO_2 + 130{\cdot}4 \text{ k.cals.}$$

* Proc. Roy. Soc., 1924, 105A, 626.

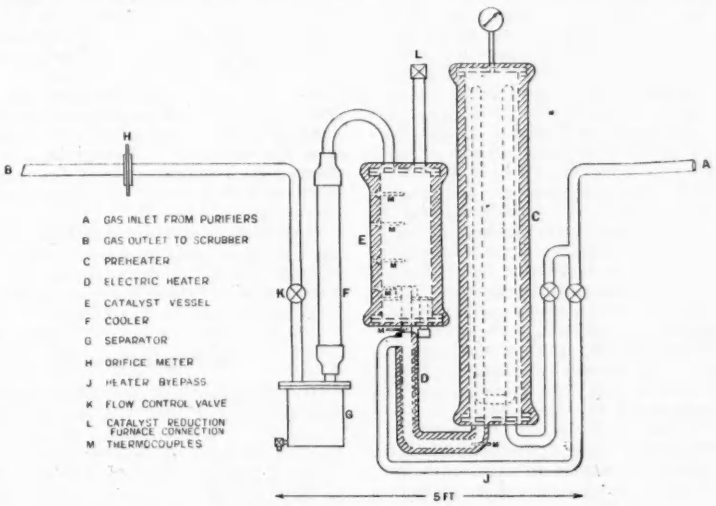
The very great heat of reaction of the combustion of carbon disulphide is evident, and it is not surprising to find that the tendency for this reaction to occur, even when the ratio of hydrogen to oxygen is about 100 : 1, is outweighing other changes.

The gas leaving the catalyst vessel was found to contain some ammonium sulphate due to the interaction of sulphuric acid with small quantities of ammonia, either present originally in the gas or produced by other reactions, in the catalyst, from cyanogen derivatives or nitric oxide. The cooled gas which had been scrubbed with soda-ash solution was found to have no sulphur dioxide, no hydrogen sulphide, less than 1 gr. per 100 cu.ft. of carbon disulphide and a total sulphur content of about 4 gr. per 100 cu.ft., most of which was thiophen or carbon oxysulphide. The mercaptans originally present in the gas had disappeared.

The temperature at which the process is operated can be very easily controlled by adjustment of the oxygen content of the inlet gas. The amount usually required to give satisfactory removal of nitric oxide and of sulphur compounds is between 0·6 and 0·7 per cent.

The oxygen consumed by the carbon disulphide is relatively very small so that it must be assumed that a volume of hydrogen equal to 1·3 per cent. of the total gas is burnt. This is equivalent to a loss of 0·6 therm per ton of coal and represents a charge of about 0·1d. per 1,000 cu.ft. of gas.

The combustion of the hydrogen and the complete elimination of oxygen result in an increase of calorific value, which in certain cases will permit more benzole to be extracted or more steam to be used in the retorts. In addition to this charge there would be pumping costs and capital expenditure on the necessary plant.



Catalytic Purification Plant.

In a larger plant which has been designed for the treatment of 2 mill. cu.ft. per day, 70 cu.ft. of catalyst space are to be provided, with a reserve of an additional 30 cu.ft. The entire heat requirements of the process will be provided by exchange between outgoing and ingoing gas. It is expected that the gas which has been treated by this catalytic process and then with active charcoal for the recovery of benzole will have a very low total sulphur content; it may well be below 1 gr. per 100 cu.ft. The benzole recovered from the charcoal should also be of superior quality in view of its low sulphur content.

The catalyst used in the original process of the South Metropolitan Company for the conversion of carbon disulphide to hydrogen sulphide appears to differ in two respects from that here described: (*a*) It was prepared from nickel chloride by the action of coal gas at a high temperature, without the intermediate production of the hydroxide, (*b*) it was deposited on a different support material. Under the conditions of experiment now employed, there is no indication of the deposition of carbon on the catalyst, even when the working temperature has been deliberately raised to 450° C.

It is interesting to note that in some small-scale experiments, where a higher proportion of nickel to carrier was used, sulphur balances could not be obtained until the catalyst had been in use for several weeks, as the formation of nickel sulphide was still taking place. Only when this process was complete could the oxides of sulphur be detected at the outlet. The catalytic treatment now employed does not lead to loss of carbon monoxide by its conversion to hydrocarbons; changes of this kind occur if

gases containing oxides of carbon and hydrogen are passed over metallic nickel, but that class of catalyst is very easily poisoned by sulphur. It appears that sulphides of nickel or cobalt do not function as catalysts for the synthesis of hydrocarbons.

In conclusion, attention may be drawn to the fact that coal gas treated in the manner here described contains no oxygen or nitric oxide, very small concentrations of carbon disulphide, mercaptans or carbon oxysulphide and a considerably lower percentage of diolefine hydrocarbons than it had originally. It should therefore be entirely free from troubles due to the formation of gummy deposits and should be capable of combustion in a flueless appliance with the formation of only traces of sulphur oxides.

Discussion.

Advantages of Sulphur Content Reduction.

Dr. E. W. Smith: The Research Executive Committee and the Institution Council are very much indebted to Mr. Hollings for having agreed to bring about this separate symposium on sulphur. It is a thankless job, because immediately he started to make his arrangements and to make his enquiries he found there was practically no work going on in the Gas Industry that was in a form which could be published, apart from the work that they were doing, and I know that he felt extremely diffident in arranging an afternoon's discussion in which all the contributions were from the Gas Light and Coke Company, but we do not regret it. This question of sulphur is probably the most important matter that the Gas Industry is tackling to-day. If we can only use gas in controlled quantities for space heating without a smell of sulphur, whether accidentally or actually, we have got an enormous weapon in the future for the extension of the use of gas. Further, most of us are worried about losing the domestic lighting load. We know that the chief deterrent in the continued use of gas in the better-class houses is not only the possibility of the smell of sulphur, but also the difficulty due to incomplete combustion. Now we are tackling this question, and I think we have succeeded in putting on the market modern equipment that no longer gives trouble as regards smell and incomplete combustion, but we have not yet got the sulphur down sufficiently low to be completely free from the smell of gas in unventilated rooms using gas lighting, and as soon as we get rid of that it will be a great advantage in gas lighting, both from the quality of the light and from the heat it gives in working-class houses. Consequently, anything that can be done to encourage this work on the reduction of sulphur should be done.

I hope that every undertaking in the country has taken advantage of reading that very fine contribution, the medical report prepared by independent medical men on the use of gas for space heating. I understand there have not been too many applications for that report, but I think that any who have not read the report of the Committee on heating with flueless heaters should get that report and determine the extent to which it can be applied in their own undertaking. Mr. Hollings has given me the shock of my life in his Paper in pointing out this new light sulphur that is present in gas. I must own that I never suspected it in anything like these quantities, and it has altered my whole point of view as to the means of attack for the elimination of sulphur. Although no tests have been carried out under my supervision, we have frequently come across the discrepancy between different methods of test for total sulphur in gas and we could never explain the differences. It never occurred to us that there was something other than CS_2 and thiophene in the gas which was possibly causing trouble. Any oil washing process can reduce sulphur, from what Mr. Hollings says, and I think we must get below the 8 grains, but this should not discourage anything which can economically develop the oil washing process, using it and getting down to 8 grains, although I think it ought to be a matter for every gas undertaking to get below 8 grains in the future. After all, 8 grains is pretty good when you have been in the habit of turning out 20 or 30 grains, but the more it can be reduced the better. Let us stick to evolution and not wait for revolution. The catalytic process, if it can be shown in the plant that is to be built to be economic—and when I say economic I mean economic not only for its own sake in the reduction of sulphur, but economic in taking into consideration all other processes which reduce naphthalene down to negligible quantities and may in some cases dry the gas—taking into consideration these things, if after that it can be economic. then there is no doubt it is an advantage to have a catalytic process which is independent of benzole washing, because we do not want to have the two tied up together unless it is essential. One disappointing thing—and I do not blame Mr. Hollings for it—is that we have asked him and his collaborators to give us this introduction to this subject rather prematurely from his point of view. At any rate, that is what I think. I do not mean prematurely from the technician's point of view, but from the Industry's point of view and his point of view it is a little early to ask him, in fairness, to leave a big demonstration plant and get down to an economic plant and then to be able to compare the different methods of sulphur removal that he has been associated with in order to give a lead to the Industry as to the best technical method and the most economic method to adopt. This involves the question of cost, and I propose to say a little more on that in a moment if I am allowed the time.

In discussing costs I think Mr. Hollings is a little confusing. He lays stress on the cost of reduction of CS_2 in the oil process and gives a figure of 1·3d. per gallon for taking sulphur out of the benzole. From a number of plants working in this country in bulk the figures that they are getting to-day from distillation methods are 0·225d. per gallon, and by chemical methods 0.354d. per gallon. The smallest distillation plant that is practicable has a capacity of about 50 gallons of crude benzole per hour, which at 3 gallons per ton means a 400 ton per day plant, which is rather a big one. The capital costs, however, would not amount to more than 0·042d. per gallon, and therefore there is no reason to believe that this process would not be justified on a 100 tons per day carbonizing plant. As I say, Mr. Hollings's view may be that this symposium with regard to costs is a little premature. However, I would like to see the costs arranged somewhat as follows so that they would be sufficiently broad and definite for us to apply our own local figures and not have to deduce things too much. I would like to have, in any given example, the relative costs of making gas without benzole production; secondly, the same gas making with benzole production, and thirdly, the cost of making with benzole removal, oil washing, and CS_2 removal. Then I would compare them and see what the extra cost of taking out the CS_2 would be, after giving credit for any other conditions which would arise if CS_2 removal were not adopted, such as refrigeration, if it were adopted, or naphthalene removal.

Another important matter which Mr. Hollings has shown us is likely to have great advantages is vacuum distillation, and his steam figures are very good. Of course, vacuum distillation can be adopted and can give similar advantages to other methods of CS_2 removal.

Refrigeration for CS_2 Removal.

Mr. Hollings has suggested that I should say a word on the subject of the possibilities of refrigeration for CS_2 removal. Mr. Hollings is using between 300 and 400 gallons of wash oil per ton of coal, but with refrigeration it is possible to get down to less than half of that. There is the cost of the refrigerating plant and the cost of the steam on the refrigerating plant, and at first blush it would appear that Mr. Hollings' method has a very big advantage. If it were possible for a large Company like the Gas Light and Coke with their resources to try out on a moderately large scale the refrigeration method, I think it would be a very good thing to get that experience for the Industry as a whole, not so much directly because of the CS_2 removal, but because of the possibilities in other directions. I have some figures here which may be of interest in connection with capital costs on a purely comparative basis. Taking a works with a one million cu.ft. per day output, with and without refrigeration—*i.e.*, oil washing, with and without—the cost of the benzole plant is about £2,500, whereas the extension plant for refrigeration, including the refrigeration plant and extra coolers, would be about £6,000. In the case of a 10 million cu.ft. per day works the cost of the oil washing plant without refrigeration would be £10,000, and with refrigeration £21,900, a very big increase in capital cost, but when you come down to working out the capital cost of CS_2 removal, as far as I can see, allowing quite a lot for contingencies, the cost for a one million cu.ft. per day works with refrigeration is about 1d. per 1,000 cu.ft. and in the case of a ten million cu.ft. per day works it is about ½d. per 1,000 cu.ft. Therefore, I put it to you that whether the refrigeration method is possible or practicable or worth consideration or not, that 1d. per 1,000 cu.ft. is not too much to pay for the complete removal of sulphur from gas, and if it means we have to pay 1d. per 1,000 cu.ft. in the future it will be well worth it as a means of increasing business. Then the question comes that with refrigeration you have one or two advantages as with some other processes as regards reducing the gum, making the gas dry, and eliminating naphthalene. Dr. Schuftan has shown that it is possible to produce a reliable process for benzole with no more sulphur in it than in the normal benzole washing process.

Finally, leaving this general question, I would like to

say the more one goes into the reports of the Research Committees and reads the reports that are coming from the Gas Light and Coke Company with such regularity and such usefulness, the more one feels that they ought not to be thrown into the pit for people to take them out and drop them as they think fit. There ought to be some directive power within the Industry that will indicate a broad policy for gas engineers. To-day it is left too much to the individual discretion, and too often you have Committees and, I will not say unpersevering engineers, but engineers who have difficulties with their Committees, but if they could only say that The Institution of Gas Engineers or the British Gas Federation urge that we must make good coke, that we must make dry coke, that we must extract benzole and that we must take sulphur out, it would be a very great advantage. There is no compulsion, but if it is said we ought to do these things I think a great deal more would be accomplished and there would be a great deal more co-ordination within the Industry along the lines that the whole of the Industry is requiring.

Fischer-Tropsch Process.

Dr. ERNST SCHINDEL: Mr. Hutchison has described an oil washing plant which employs a large circulation and has shown that not only can the sulphur content be reduced to 8 to 10 grains per 100 cu.ft., but that by careful design of heat exchange appliances, it has been possible to keep the steam consumption down, and although this is a little higher than on an active carbon plant, the performance reported is truly remarkable for an oil washing system.

In this connection it should be borne in mind that the benzole plants at Beckton and at Harrow, the results of which have been reported by Messrs. Hollings and Hay, were designed primarily as benzole extraction plants and not as sulphur extraction plants. If there should be a real desire for a lower sulphur content in the stripped gas, and should the Gas Industry be willing to pay something, however small it may be, for the removal of this suiphur, it must be understood that the carbon process can carry the reduction considerably further than has been done in these plants. The data given in the Paper of Hollings and Hay show clearly the possibilities in this direction.

I do not wish to belittle the achievements of the new oil washing system, but I think it is fair to mention that there is a very great difference in fundamental physical principles between the carbon process and the oil washing process. The process of absorption in an oil is such that if it were desired to reduce the sulphur content from 10 grains per 100 cu.ft. to 5 grains per 100 cu.ft., this would not only add substantially to the capital cost but the expenditure of heat and energy would be greatly increased. It is, however, an outstanding characteristic of adsorption by activated carbon that the consumption of heat and power per unit weight of extracted material does not increase very much with increase of extraction efficiency. This arises from the fundamental physical differences between *ab*sorption and *ad*sorption. For this reason, in Germany, where at the present time home produced motor spirit is regarded as extremely valuable, carbon adsorption plants are used to remove gaseous hydrocarbons from coal and coke oven gases which have previously been stripped of benzole by oil washing plants or by normal benzole extraction plants of the carbon adsorption type.

In the Fischer-Tropsch synthesis of hydrocarbons the carbon adsorption process has been adopted in many installations on an impressive scale. Whereas a few years ago Beckton was the largest plant of its kind in the world, in point of capacity it is now surpassed by the carbon adsorption plants used in connection with the Fischer-Tropsch process.

The essential point I wish to make is that whereas Mr. Hutchison has shown that it is possible by extremely careful design to achieve results in sulphur extraction and energy consumption approximating to those of the carbon plants at present installed in this country, it should not be forgotten that the carbon adsorption process, by reason of the fundamental physical principles, possesses a greater margin of elasticity, and sulphur extraction can be carried economically with this process still further, whereas I believe that the results reported by Mr. Hutchison must represent an upper economic limit beyond which, in the present state of knowledge, it will be difficult to go.

The statement made at the end of Mr. Hollings's Paper that it is intended to apply the catalytic purification of the gas as a preliminary to the oil washing process as well as a preliminary to the carbon process, is one of the greatest possible interest. It is to be expected that under such conditions the carbon process should produce directly a benzole which requires no further treatment, as it would be entirely free from impurities such as are derived from wash oils in absorption plants. Apart from the possibilities existing with regard to sulphur removal, the active carbon process becomes of ever growing importance in connection with the refinements in gas purification, and is particularly important when coke oven gas is transmitted over long distances. Time does not permit of a detailed discussion of this point, but I should like to mention that a large coke oven plant—namely, the G. B. A. G., has decided to install the active carbon process for the secondary purification of 80 million cu.ft. of gas per day. The gas is treated at a pressure of 100 lb. per sq.in., and it is obvious that such pressure plants are considerably reduced in size and hence become an economic proposition.

Some Details of the Plant.

F. M. BIRKS (Gas Light and Coke): The Author almost offers an apology for the size of the experimental plant; there is some precedent, however, for such a decision. Was it not the late Admiral Lord Fisher who is reported to have stated that the best scale for a model is full size? In considering the figures of steam consumption, it is important to note that pound for pound the value of the steam supply varies to some extent with the continuity of the demand, and as the steam supply to this plant is at an even rate it is obvious that there will be little or no inconvenience suffered on the steam raising plant of the Works, as is the case with a fluctuating load.

Apart from technical considerations this plant should be welcomed by the accounting side because all the power required is obtained during the expansion of the process steam to the plant itself from its initial high pressure to the low pressure at which it is used for heating and distilling the oil. Therefore, no abstruse calculations of heat balances are necessary in order to assess relative values of high pressure steam, exhaust steam, and electricity, and a simple measurement of the input of high pressure steam is all that is required to obtain an accurate cost with regard to charges for steam and power.

Apart from any such considerations steam engines are preferable to electrical motors in benzole plants on grounds of safety, and reference to Table 13 shows that this precaution is realized without the wasteful discharge of any exhaust to atmosphere at least in the normal method of working using the mechanical vacuum pump. Another simplification in determining costs arises from the fact that the plant is self-contained as regards means for re-cooling the water used, and since this water is recirculated by means of a pump coupled in tandem with one of the oil pumps, the cost of water need only be taken as the cost of make up to the cooling tower, a figure which can be readily ascertained. Secondly, as far as the mechanical equipment is concerned, the pumps are as stated of normal design, the only problem that presented any difficulty being the dealing with oil at high temperature from vacuum to high pressure and the impossibility at the present time of producing a gland for a shaft running at high speed, which will remain permanently absolutely tight. The usual design of gland for inflammable spirits was used, that is, double glands with a lantern ring between each section, to avoid air being drawn into the pump, a slight pressure of oil is kept at the lantern, and all leakage is external, where it can be collected and piped back to the storage tank. The glands of the cold benzolized oil pumps are of similar design, but in this case no external leakage can be allowed, so that instead of a pressure being retained the lantern ring is connected by pipes to the tanks, and any oil passing the first gland section is drained back without external leakage. The other point of interest is the vacuum pump, a simple single cylinder double acting machine fitted with a heavy fly wheel, and running at about 60 revolutions a minute, driven by a diminutive steam turbine.

Kensal Green Benzole.

G. CLAXTON (Gas Light and Coke): If a gas-works is sufficiently fortunate to be able to refine its own benzole, it is clear that the extra cost of refining a benzole such as that mentioned in the Paper will be chiefly the cost of taking out the extra carbon disulphide that has been recovered. Assuming that the benzole contains about 1 per cent. of sulphur as carbon disulphide, the cost should be not more than 0·7d. per gallon, and I presume that it is on this basis that Mr. Hollings has made his statement that the value of the Kensal Green benzole is only 0·65d./gallon less than that of an equivalent normal benzole.

What, however, is the position of the gas undertaking that is selling crude benzole? Under the existing scheme of selling crude benzoles by the retort test, no cognizance is taken of the extra sulphur. This extra sulphur and other compounds simultaneously recovered will merely increase the bulk of the benzole by about 1 per cent. so that, apart from the extra cost of running the modified benzole plant, the sulphur removal has cost nothing. In fact, the purchaser of the benzole has been induced to part with a slight bonus for the privilege of taking this benzole of inferior quality. If any means of evaluating crude benzole

were introduced, such as Mr. Hollings has visualized, that took cognizance of the sulphur content, it is difficult to picture a workable scheme based on anything but average data. A benzole such as the Kensal Green benzole, in which presumably about 1 per cent. of the sulphur is present as carbon disulphide the remaining ½ per cent. is present as thiophen, &c., is not average.

The average high-sulphur coke-oven benzoles, such as those produced on the Yorkshire coal fields, contain about equal quantities of thiophen and carbon disulphide sulphur, the thiophen sometimes reaching nearly 0·8 per cent. by weight. It is clear that in order to refine such benzoles, the use of strong sulphuric acid would be necessary with a consequent loss of product amounting to perhaps as much as 5 per cent. Thus the refining by virtue of the loss of product alone would cost about 0·85d./gallon more, making the total cost of 1·3d./gallon mentioned by Mr. Hollings quite a reasonable figure for the average benzole of 1·5 per cent. total sulphur.

Until such time as these new gas-works benzoles become the rule and not the abnormal, there would seem to be no alternative but to base the costs of sulphur removal from the gas on what the benzole would fetch in the average market. Provided that, when costed in this way, the Gas Industry is satisfied that the improvement has paid for itself, I cannot see what harm would be done if the purchaser of the crude benzole were able to refine the benzole for a little less than he could an average benzole. He has come to the rescue of the Gas Industry, he has gambled to some extent on high evaporation and polymerization losses due to the extra quantities of low-boiling compounds in the benzole, and that little extra profit, if it ever materialized by the time he had refined the benzole, would be his reward for taking the unwanted sulphur from the gas undertaking. It would be what he was paid for "carting it away." I have no doubt that the Industry is not very interested in what becomes of the sulphur once it is taken out of the gas. From the benzole producers' point of view, however, sulphur is an unmitigated nuisance, and from this point of view the catalytic process has definite attractions.

A Step Forward.

Dr. MACFARLANE: In this symposium I have found the third Paper by Dr. Griffith particularly interesting. I should like to be quite clear, however, whether his particular method of catalyst preparation is essential for the combustion of organic sulphur compounds. It would appear from his Paper that he was investigating the reduction of nitric oxide when he experimented with different supports, and that the efficiency with which the catalyst purifies gas from sulphur compounds was incidental. Again, I should be grateful if he could specify more precisely his reaction temperature. I see that he indicates that the inlet temperature of the gas was about 150° C., and he states that the reaction is exothermic. Dr. King in his recent William Young Lecture urged the need of removing organic sulphur compounds from town gas. He is unable to be present this afternoon, but he has asked me to say how gratified he is to hear of this step forward, and to add his congratulations to Dr. Griffith. Dr. King described certain preliminary experiments carried out at the Fuel Research Station in connexion with the synthesis of hydrocarbons. I can now give some further data on this subject. For this purpose it is essential to remove organic sulphur compounds to a far greater extent than the 4 grains/100 cu.ft. that Dr. Griffith states his exit gas contains. The permissible limit of sulphur is said to be 0·2 gram/100 cu.m., or less than 0·1 grain/100 cu.ft. An iron oxide-sodium carbonate catalyst will effect this purification at a temperature of 230° and a space velocity of 200. The catalyst retains the sulphur and remains efficient until it contains about 5 per cent. of its weight of sulphur; it can then be used in oxide boxes for the removal of sulphuretted hydrogen. It may be as well to state that for laboratory scale experiments a higher temperature is necessary.

The efficiency of the catalyst falls off sharply as the content of organic sulphur compounds in the gas increases, but purification is complete with water gas containing up to 30 grams of organic sulphur/100 cu.m. When chamber-oven gas containing 70 grams/100 cu.m. (30·6 grains/100 cu.ft.) was treated, it was only possible to reduce the sulphur to about the same figure that Dr. Griffith has mentioned—7·8 grams/100 cu.m. or 3·4 grains/100 cu.ft.—and to do this the space velocity had to be reduced to 110. No doubt the ease of preparation and lower cost of the iron-oxide sodium carbonate catalyst would compensate to some extent for the far lower space velocity as compared with Dr. Griffith's catalyst. Finally, I should like to ask Dr. Griffith whether he has experimented with the copper-vanadium catalysts mentioned by Huff and Logan in the 1936 Proceedings of the American Gas Association. For these catalysts efficient purification at space velocities of 3,000 to 15,000 is claimed.

Mr. P. M. SCHUFTAN (Richmond): In connexion with Dr. Griffith's Paper I should like to mention some observations concerning the catalytic reduction of NO partly published eight years ago.* Trying to simplify the NO-determination in town gas, I hydrogenated the NO into ammonia over a copper catalyst and determined the amount of ammonia thus formed. I also found the activity of the catalyst soon decreasing by increasing formation of copper sulphide, due to organic sulphur compounds. In further experiments the interaction between NO and metal sulphides was studied. At low NO-concentrations and at normal temperature formation of Roussin salts was observed, but when concentrated NO is brought into contact with iron sulphide a reaction with considerable development of heat takes place, and the NO proved to have been reduced to N_2O with simultaneous production of only small amounts of ammonia and nitrogen.

It would be interesting to know if in the process worked out by Dr. Griffith the NO-elimination is also due to a reduction by nickel sulphide under formation of N_2O.

Steam Consumption Figures.

Mr. C. COOPER: The interest of Mr. Hutchison's Paper for me lies in the steam consumption figures, which are claimed to be low in virtue of the adoption of working the still under vacuum. As a matter of fact, I would prefer the steam figures to be quoted as pounds per gallon of oil circulated, rather than as pounds per gallon of benzole recovered. The implication is the same as in Mr. Hollings's Paper, that the expenditure has to be covered by a revenue which is not necessarily provided in the competitive processes. Prior to the work described, I should imagine that the lowest steam cost on a benzole recovery plant would be that quoted by the Wilputte Coke Oven Company, which I believe was under 0·5 lb. of steam per gallon of oil. The system was to use substantially all the steam in the still, and to preheat the oil by heat exchange with the outgoing oil and with the steam and vapours. The steam consumption given by Mr. Hutchison is about 0·32 lb. per gallon. Analyzing the system of using all steam for stripping, it appears that the bare minimum possible is about 0·2 lb. per gallon, and that each 1° F. by which the preheat fails to attain 212° calls approximately for a further 0·005 lb.

Taking the *qk* and *qrkr* figures specified by Mr. Hutchison (which are, of course, his own choice), these minimum figures are raised to 0·31 and 0·008 respectively, so that a preheat by heat exchange within 20° F. of the ideal would result in a consumption of about 0·47 lb. per gallon. However, this failure to meet the low figure of 0·32 lb. quoted above is not necessarily a total failure. The simpler process can absorb exhaust steam from other sources, as the steam released from the pumps is not sufficient, except perhaps on small and less efficient units, to provide the full 0·47 lb. per gallon. I mention this because the design of the plant described is based on the assumption that such a plant must be self-contained in its steam and water requirements—an assumption which is a little unnecessary, perhaps. It may be agreed that with all these conditions assumed, the installation of a vacuum still, and the particular choice of pumping and heat exchange systems are the best for the circumstances, but this will not apply for all cases. Incidentally, it is to be noted that the statement that they considered that 80 per cent. of the benzole should be recovered requires to be regarded against a specific steam cost, which is not mentioned in spite of its importance.

In Mr. Hollings's Paper, there appears to be undue emphasis on the actual cost, chiefly the steam cost, of the desulphurizing process based on oil washing and distillation. Sulphur extraction will stand some actual cost, on its merits, and in the average case need not pay as a manufacturing process. In the case of the alternative processes, such as the projected catalytic hydrogenation processes, a net cost is likely to be incurred. Benzole extraction economics must be a separate study, although it is more than probable that an undertaking now practising some caution as to the extent of debenzolizing would increase its benzole extraction, given the higher capacity implied in the desulphurizing process, and work nearer the margin of economical working.

Mr. E. V. EVANS (South Metropolitan): In congratulating Mr. Hollings and his colleagues, I cannot refrain from commenting on the swiftness with which they have reduced the practicable limits for the desulphurization of gas. From discussing ways and means of reducing the sulphur content to 10 grains per 100 cu.ft., Mr. Hollings has in no more than a year moved to the point of showing us the possibility of producing gas containing only one or two grains per 100 cu.ft. The work also that Mr. Hutchi-

* Zeitschr. f. ang. Chemie, 42, p. 757 (1929).

son has carried out in improving the oil washing process is really an outstanding example of the advantages to be obtained when they are painstakingly analyzed by physical chemists and then reconstructed with knowledge and imagination. My chief interest, however, naturally lies in the new catalytic process described by Dr. Griffith and those who have worked with him on catalytic hydrogenation. I speak of hydrogenation of carbon bisulphide, and I am proud to remember that Mr. Hollings was one of us who have realized the great practical importance of being able to lower the temperature necessary for the reaction. Not only would this reduce the fuel costs and the cost of wear and tear on the plant, but it would to a large extent overcome the fouling of the catalyst by deposited carbon which happens in the case of this reaction on hydrogenation. With this object in view we have in the past tried many modifications of the nickel-sulphide catalyst, and we have, in the course of that work prepared catalysts in somewhat the same way that Dr. Griffith had. Our most promising results were obtained when we used a promoter, thorium oxide, in conjunction with the nickel catalyst and that allowed the reaction to take place at a much lower temperature. It may be that this will be of some help to Dr. Griffith, but below 250° F. we found that hydrogenation—and you see all the time I am talking of hydrogenation which is rather different from this present invention—proceeded too slowly to be of practical interest, and consequently we did not carry out any work below this temperature. In studying the reduction of carbon bisulphide we did not think of the possibility of its oxidation with the self-same catalyst, and it may be that in looking for the gold we missed the diamond. Since the first reading of this really most important discovery I have renewed my belief that we have great cause for gratification in that research work in the Gas Industry is not left in any one pair of hands or with one group of workers. Had it been so this development would almost surely have been missed by us, for I believe that we in the South Metropolitan Gas Company are too well wedded to our original work to have made this discovery. Is there not in all this, perhaps, the answer to those who advocate the formation of an all-embracing and all-inclusive research institute which might enshrine and even embalm the best brains of the country.

Mr. Hollings Replies.

Mr. HOLLINGS: The day I began my work in the Gas Industry I was met by Mr. Evans, who outlined a programme of work which I was to carry out upon the sulphur compounds in coal gas. I have always felt it was a great privilege to be associated with the now classical work which Mr. Evans carried out with Dr. Carpenter. It is a compliment that he should be here to-day, and I am very appreciative indeed of his very generous remarks. One or two references have been made to what Mr. Hutchison has more recently found concerning the occurrence of other more volatile compounds in coal gas. I would just make the point that these compounds have only been found under conditions which Mr. Evans could not offer me, because they only came to light since we started to work with gas made in continuous vertical retorts. May I say that I am also very grateful to Dr. Smith and to Dr. Claxton for their references to the cost of removal of benzole, but may I express disagreement with Dr. Smith that the question of cost is premature, because my view is that whatever may be the cost of removing carbon bisulphide from the benzole when we have recovered it, that cost expressed as so much per unit of gas treated is so small a price to pay for having a low sulphur gas that we should get on with the work anyhow.

Ist Report of the Pipes Committee

Communication No. 170

The Council of The Institution of Gas Engineers, on 9th July, 1935, disbanded the Pipes Sub-Committee and appointed in its place a Pipes Committee, with Mr. H. J. Escreet (London) as Chairman, to deal with all matters relating to Pipes and problems arising therefrom.

The Pipes Committee reviews all important reports, specifications and other publications dealing with Pipes and collaborates with the relevant Committees of the British Standards Institution. It has considered, *inter alia*, draft British Standard Specifications concerning:

(*a*) Cast Iron Pipes for Water, Gas and Sewage.
(*b*) Malleable Cast Iron and Cast Copper Alloy Pipe Fittings.
(*c*) Rubber Rings for Joints in Water, Gas and Sewage Mains.
(*d*) Rubber Joint Rings for Gas Mains.
(*e*) Wrought Iron and Steel Pipes (Screwed and Socketed) for Gas, Water and Steam.

The Committee desires particularly to obtain information as to experiences with and special tests of relatively new materials and methods relating to Pipes and gas distribution work, and it appeals to members of the Institution to send to the Secretary, for its consideration, particulars of any such experiences and trials so that matters of general interest may be included in subsequent Reports of the Pipes Committee.

ESCAPES OF GAS INTO CABLE DUCTS AND MANHOLES

Discussions have taken place between representatives of The Institution of Gas Engineers, the National Gas Council and the Post Office, to consider the question of making more effective the precautions taken by the Post Office to prevent, as far as it is able, gas explosions and the risk of Post Office workmen being affected by the presence of gas in Post Office manholes, and to ensure closer co-operation in this matter.

The following notes on (*a*) access to Post Office telephone jointing chambers and removal of covers to surface entrances to Post Office plant, (*b*) methods of dealing with escapes of gas into cable ducts and boxes, and (*c*) a simple detector for carbon monoxide, are printed with the approval of the Post Office Authorities.

(*a*) ACCESS TO POST OFFICE TELEPHONE JOINTING CHAMBERS AND REMOVAL OF COVERS TO SURFACE ENTRANCES TO POST OFFICE PLANT

The Post Office, in order to assist in the clearance of gas leakage, agrees to afford any necessary facilities for access to jointing chambers and in the temporary removal of manhole covers for tracing and ventilation purposes, subject to the following conditions:

(i) In an emergency covers may be removed for ventilation purposes without prior advice to the Post Office.

(ii) When covers are removed for emergency reasons the Supervisor of the local Telephone Exchange or the Post Office Engineering Department will be advised accordingly by telephone as soon as practicable.

(iii) The party removing the covers will be responsible for general safety whilst the jointing chamber is open, and for safe replacement of the covers either until inspection by a Post Office representative or for 24 hours after the Post Office is advised of their replacement.

(iv) Employees of Gas Undertakings should enter Post Office manholes only when a Post Office representative is present. Requests for attendance of a Post Office representative will be dealt with by the Telephone Exchange Supervisor or the Post Office local Engineering Department as urgent emergencies. Tests for the presence of gas can usually be made without actual entry into a manhole.

(v) Under normal circumstances not of urgency or emergency the attendance of a Post Office representative should be arranged for before covers are removed for either ventilation or entry.

(*b*) METHODS OF DEALING WITH ESCAPES OF GAS INTO CABLE DUCTS AND BOXES

The arrangements made for closer co-operation between the engineers of Gas Undertakings and those of the Post Office Telephone Service have suggested that some notes upon the methods of dealing with escapes of gas into cable ducts and boxes may be of interest. Those in charge of the distribution systems of large towns are no doubt fully conversant with the difficulties of tracing such escapes and

the methods of overcoming such difficulties, but engineers in rural districts may not be so familiar with the best methods of dealing with these problems.

Underground telephone cables and many electricity supply cables are laid in duct lines, usually made up of short earthenware pipes. These may be single pipes or blocks of several pipes made into one duct. Duct lines are sometimes laid with butt joints, the whole duct being surrounded by concrete, but in most cases, a spigot and socket joint is used, the space in the joint being filled with a bituminous jointing compound in order to prevent the ingress of water. Unfortunately, these joints are seldom tight enough to prevent leakage of gas from an adjacent main entering the line of ducts.

To provide for the drawing of cables into the ducts and the jointing together of the lengths of cable, manholes or jointing boxes are provided at intervals.

The various duct lines serving a district are interconnected at the jointing boxes, and therefore a leakage of gas into a duct may spread a long way through the system if it is not detected and remedied without delay.

The two principal difficulties in connexion with escapes of gas into cable ducts are:

(i) The difficulty of locating the source of escape, since the report of leakage may originate at a box or manhole on the duct line some way from the point at which gas is entering the ducts.

(ii) The risk of explosion due to the mixture of gas and air in the ducts and boxes.

The first step in dealing with any escape into a duct system is to give ventilation by the raising of box or manhole covers; this will allow the gas to clear from the boxes and will prevent it from spreading further afield. The dangers of explosion are reduced, and location of the escape made easier. In the case of a considerable escape, it will probably be found that, after the boxes in which the presence of gas was reported have been ventilated for a short time, several of them are free from gas but that gas is still present in at least one, that one will be the one nearest to the source of the escape. In such cases, this box and the boxes on either side of it should be kept open for ventilation purposes, while the escape is located and remedied.

In the case of a small escape, it may be found that the opening of the boxes for a short time will result in the removal of all smell or trace of gas. Under these circumstances, it is often useful to stop up the ends of the ducts —where they enter the boxes—with clay, and test an hour later by means of an indicator on a small hole through the clay; by these means, it is probable that the section of ducts to which the gas is obtaining access can be located.

MAKE EXPOSURE WHILE PAPER IS STILL
MOIST WITH SOLUTION.
EXPOSE FOR FIVE MINUTES.
DANGER IF COLOUR IS DARKER THAN DARK BUTTON
CAUTION IF COLOUR IS BETWEEN
LIGHT AND DARK BUTTONS
SAFE IF COLOUR IS LIGHT

FIGURE 1.—*The Carbon Monoxide Detector.*

It should be noted that the clayingup of the ducts should only be done by or in the presence of an employee of the owner of the plant, and care must be taken to avoid any damage to the cables or, in the case of power cables, any shock to the men.

When it is desired to clay up ducts in a large manhole, *i.e.*, a manhole which must actually be entered in order to reach the duct, a gas mask or other form of distant breathing apparatus must be worn by the man entering the manhole, unless it is certain that it is practically free from gas.

The stopping up of the ducts is often particularly useful when dealing with the presence of gas in a junction box at which several separate duct lines join. The particular duct along which the gas is entering the box may be determined by this method.

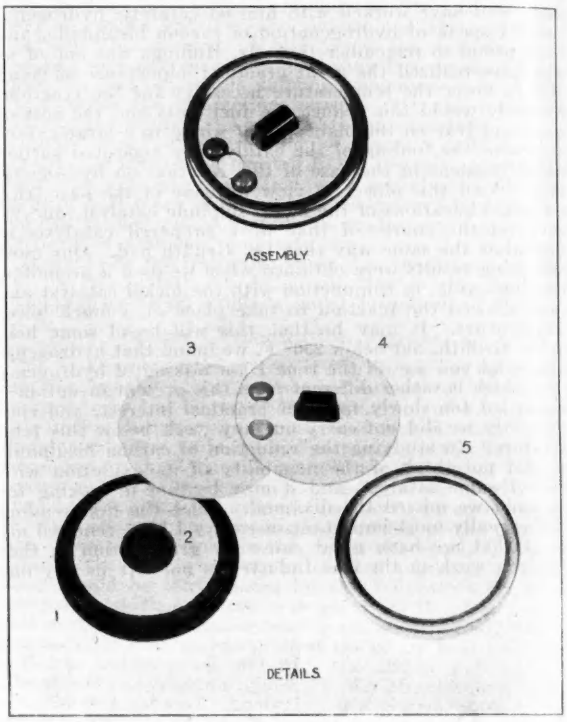


FIGURE 2.—*Details of the Carbon Monoxide Detector.*

It should be emphasized that the opening of boxes in the vicinity of an escape for ventilation is always desirable, and should not be confined to those cases in which the escape is reported to be entering the boxes. One of the first steps in dealing with a serious escape in the neighbourhood of cable ducts should be the examination of all the boxes in order to find whether or not the gas is entering the duct system. If gas is found in the boxes, they should always be left open for ventilation.

(*c*) A Simple Detector for Carbon Monoxide

With the dual purpose of reducing risk of explosion and of affording warning of the presence of carbon monoxide in underground chambers and conduits, the Post Office has recently adopted a simple form of detector devised by two members of the Engineering Staff (Barralet and Richards, British Patent No. 396672), which, although cheap and requiring little skill to use, is capable of detecting carbon monoxide in concentrations as low as 0·05 per cent.

The device depends upon the fact that palladium chloride solution is darkened by carbon monoxide and that the degree of darkening in a given time depends upon the amount of carbon monoxide present.

Figure 1 shows the complete Indicator with tube containing the palladium chloride testing solution packed in a small metal box suitable for carrying in the pocket.

Figure 2 shows the details of the Indicator, which will be seen to consist of six parts:

(1) The base, which is made of bakelite and contains
(2) A Sorbo rubber disc.
(3) A plain pressure plate, which lies on the Sorbo disc.
(4) A top plate with a circular aperture and provided with two buttons darkened to simulate the colours to be anticipated with concentrations of the order of 0·05 per cent. and 0·1 per cent. carbon monoxide.
(5) A metal clamping ring which screws on to the base and holds the above components together.
(6) Test paper.

In assembling the Indicator for use, the reserve test papers are placed on the base followed by the pressure plate, one test paper is then placed between the pressure

plate and the top plate and the clamping ring screwed on moderately tightly so that it is possible to rotate the top plate by the handle without rotating the paper. A small area of white test paper will be visible through the aperture in the top plate.

The active material for the test is a solution of palladium chloride in acetone and water, and is supplied in a small glass phial similar to the familiar iodine pencil.

The method of conducting the test is as follows:

After the set has been assembled as described above a small quantity of palladium chloride solution is applied to the test paper by lightly pressing the aperture of the phial at the centre of the area of white paper visible through the hole in the top plate. Sufficient liquid should be applied to provide a slight excess beyond the amount required to cover completely the exposed portion of the test paper.

It is essential that the colour of the solution when exposed for a five minute test in clean air should correspond with that of the face plate. Should it be darker contamination by grease or other impurity should be presumed and a fresh supply of palladium chloride obtained.

At a manhole the cover should be raised and the Indicator suspended about mid-way down the manhole by a string or wire passed through the hole in the handle of the Indicator.

The test should be made immediately after the application of the palladium chloride solution; if the paper is permitted to become dry the test is useless.

After five minutes' exposure, the Indicator is withdrawn and the colour of the test paper compared with the colour of the face plate and the buttons on each side of the hole in the face plate. The changes in colour due to the presence of carbon monoxide take place mainly towards the end of the test period, and a full five minute exposure must be observed for the test to give accurate results.

The colour of the face plate is the colour to be expected in the absence of carbon monoxide.

In Post Office practice coloration to the extent of the lighter button is taken as a warning that the amount of carbon monoxide present at the point of test involves some risk of toxic effects, a risk which increases rapidly as the test colour approaches that of the darker button. If the colour of the test paper is darker than that of the darker button, the atmosphere is regarded as definitely dangerous and possibly explosive.

The use of this Indicator, which detects even slightly toxic concentrations of carbon monoxide, gives a wide margin of safety against explosions due to coal gas since the colour corresponding to the dark button is produced by an amount of carbon monoxide much less than that present in a concentration of ordinary coal gas at the lower explosive limit.

It is necessary to state that palladium chloride solution is affected by gases other than carbon monoxide—notably petrol vapour, ethylene and acetylene, none of which gives rise to material difficulty in practice as the resulting change in colour, a warm brown, is readily distinguished from the characteristic darkening consequent on the action of carbon monoxide. When hydrogen sulphide is present, however, special consideration is necessary, as the resulting darkening is similar to that due to carbon monoxide. Difficulty in practice is again unlikely, as hydrogen sulphide, unlike carbon monoxide, has a very characteristic odour even in minute concentrations, and would be unlikely to escape notice even in the absence of an Indicator; it is, however, definitely toxic, and even if the discoloration of the test paper was produced by this gas and not by carbon monoxide, it would be necessary to observe similar precautions. If, however, it is desired to determine definitely whether the discoloration of the palladium chloride has been produced by carbon monoxide, the discrimination could be readily made by carrying out a second test in which the test paper was moistened by lead acetate solution instead of palladium chloride. In the case of carbon monoxide, the lead acetate would be unaffected, but with hydrogen sulphide blackening would occur.

No device quite so simple and inexpensive as the Carbon Monoxide Detector has hitherto been available, and it is expected that its general use in manholes and subways will do much to reduce the hazards arising from the presence of explosive and toxic gases in such conditions.

WROUGHT IRON SPECIFICATIONS

The Pipes Committee has reviewed the Wrought Iron Specifications of The Institution of Gas Engineers, the last edition of which was published in 1930 (Publication No. 12 of The Institution of Gas Engineers). The Committee is satisfied that a useful purpose is served by these Specifications, and it is considering, in collaboration with the British Wrought Iron Association, the preparation of a Specification for Wrought Iron Bars for Gas-carrying Tubulars and Fittings. The List included in the above-mentioned Publication No. 12 of approved British Firms which are producing Wrought Iron Strip of British Manufacture conforming with the Specification of The Institution of Gas Engineers for Wrought Iron Gas, Water and Steam Tube Strip is under revision, and application to be placed on this List must be made to the Secretary of The Institution of Gas Engineers, 1, Grosvenor Place, London, S.W. 1. A similar list will be prepared of British Manufacturers in respect of the proposed Specification for Wrought Iron Bars for Gas-carrying Tubulars and Fittings.

Discussion.

P. RICHBELL (Croydon): Everyone will agree that the most difficult escapes to trace are those where an escape of gas enters the Post Office or electric duct lines, owing to the position where the escape is detected being in many cases a considerable distance from the actual defect in the distribution system. The arrangements the Chairman and Committee have made with the Post Office Authorities will be very useful to Undertakings throughout the country, particularly in districts where no co-operation exists between the Undertaking and local Post Office Engineers. In Croydon we have had a similar privilege for a number of years, and I can assure you that it has considerably facilitated the tracing of escapes. I presume the carbon monoxide detector devised by two members of the Post Office Engineering Staff is mainly used in large, deep manholes.

It has occurred to me that now the Committee have been so successful in making the arrangements with the Post Office Authorities set out in the report, whether a similar arrangement could be made with the London Passenger Transport Board. This would be very useful to Distribution Engineers in charge of distribution systems in the area of the above Authority. At present it is necessary to communicate with the local depôt and arrange for a representative of this Authority to be present before a box can be opened.

I was pleased to note that the Committee have approved B.S.I. Specifications for rubber joint rings for gas mains. In the original draft specifications for these rings they were included in the same specification as the joint rings for water and sewage mains. I was very pleased to learn that the Committee had persuaded the B.S.I. Committee to make a separate Specification for joint rings to be used specifically for gas mains. I have had an opportunity of reviewing this draft specification and, while it is a very considerable improvement on the original specification, I still feel that the three classes of rubber included in the Specification will have to be further sub-divided to cover the varied types of rubber rings used in conjunction with the laying of gas mains. In Croydon we have been using rubber rings for many years now for the jointing of our mains, and I can assure you this specification will be very useful. We are preparing a specification on rather finer limits in conjunction with the Rubber Research Association which will be used conjointly with the standard tests and other details set out in the Specification. I was discussing the question of rubber rings with the Director of the Rubber Research Association recently, and during the conversation he informed me that he had now set up a Department for testing samples of supplies from the manufacturers.

May I ask whether in the draft specification for cast-iron pipes for water, gas, and sewage which has been considered by the Committee, whether they have now been able to include the weights of specials? I would also like to know whether it is possible to prepare a B.S.I. specification for centrifugally spun iron pipes. At the present time, the only specifications available are the International Standard Specification and a Specification which has been prepared by the manufacturers of these pipes.

Great Good to be Obtained from Co-operation.

Mr. F. O. BARRALET (Staff Engineer, General Post Office): At the moment I am not directly connected with the problem of precautionary and safety measures against gas, as described in this Report; but I was very intimately connected with it a few years ago and I was a member of a Committee considering means of improving the conditions in which men work underground and the means provided for the detection of gas in dangerous conditions. I am particularly pleased to note the free way in which technical co-operation between ourselves and the gas interests are recognized in this Report. At the time I was concerned with these matters I was very much impressed by some documents published by the American Bureau of Mines, giving an account of a very extensive co-operative investigation made in the Boston area, and in which the electricity and gas interests and the Bureau of Mines were concerned. I daresay the members of your

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Pipes Committee know all about that investigation. There was one very striking example in which, by means of a systematic series of tests, the hot spots, so to speak, over a very large area were cleared up; within a year or two the manholes in which the percentage of combustible gas was rather high was reduced from about 6 or 7 to 2 per cent. Speaking from memory, I believe that during that series of tests a number of manholes in selected areas was examined about 1·5 times a year; the results indicated the bad spots, and repairs were carried out. It is interesting to note that in that particular case the investigation was made on almost a laboratory basis, inasmuch as a testing van was provided whereby samples of air were sucked from the manholes without removing the covers. That was a particularly striking example of three different interests working together to remove a common cause of trouble. Perhaps the conditions of main laying here are quite different from those obtaining in the Boston area; but the basic fact of the co-operation remains.

With regard to appliances used by the Post Office, the palladium chloride detector described in the Report, for detecting carbon monoxide, is really a very convenient and cheap means for carrying out quite a familiar test. The palladium chloride reaction is by no means new. You may be interested to know that the great Bell Telephone organization in America uses the same test, though in a different form; in their case the detector consists of a pad of cotton wool containing a tube of palladium chloride which is broken between a man's fingers and then dangled down the manhole in which the test is to be made. In considering that we rather came to the conclusion that one is just as likely to get an indication from the dirt on the man's fingers as from any gas present, and we prefer to use the detector described in the Report.

Of course, we have to consider not only combustible gas, but other gases which might be dangerous to the men—the presence of excess of carbon dioxide or the insufficiency of oxygen, which give rise to another condition altogether. For dealing with that problem we have probably to rely on the safety lamp. Where a safety lamp, especially of the miners' type, is used we have to put in three gauzes in order to ensure that there is no possibility of the lamp inflaming any combustible gas which might be present.

I have no doubt that great good will come from the co-operation between the Gas Industry and the Post Office, which is indicated in the Report; and I feel that the publication of this Report does not by any means mark the end of our contact with the Pipes Committee, because the terms of reference of that Committee embrace all sorts of investigations in underground structures, pipes, and so on, and we are very intimately concerned with many of those problems, and use materials underground which are similar to your materials. Perhaps you are not bothered with lead, which is one of our main constructional materials and which gives an enormous amount of trouble from the corrosion point of view. But the general problems of corrosion arising from stray currents, and of purely chemical corrosion, are common to both of us, and we both suffer from the same ills. I have no doubt whatever that the technical information arising from Post Office Researches on this subject (we have a large mass of data) and the technical information which you possess with regard to it could be exchanged, to the utmost benefit of both of us. We have been very intimately concerned with the question of protection, taking the view that in some cases the conditions are such that the only thing to do is to afford protection against them; it is of no use merely trying to find theoretical explanations for the corrosion which occurs. If you put pieces of material into the ground unprotected they are bound to corrode, and no amount of laboratory research will stop it; but laboratory research indicates, of course, ways and means of effecting protection. We are now trying to inhibit corrosion by introducing inhibitory reagents into the greases that we use when drawing in cables; those reagents deposit protective films on the lead and in some cases prevent corrosion. But the problems in connection with protecting iron and steel and most other metals against corrosion are probably common to both of us. If I can give any information at any time concerning Post Office practice, I shall be only too glad to do so.

Gas Industry Procedure.

Mr. W. VICKERY (Assistant Staff Engineer, General Post Office): We are in agreement with the principles embodied in the various rules. In the Post Office the agreement and instructions relating to procedure would be circulated to every exchange in the country and they would know exactly what to do in regard to the various matters reported to them. Similarly, every engineering workman in the Post Office will be supplied with information about the treatment of box covers, the tracing of leaks and so on, as agreed in the Memorandum. We should like to know to what extent and by what means the Gas Industry will circulate similar information among its employees. Again, there is the question of the form, of whether any reservations are necessary in regard to the discussions that have taken place. The Pipes Report does not deal with the offer on the part of the Institution to assist the Post Office should it be found that in some particular localities gas leakage is not dealt with promptly. Probably the procedure in that connection is unsuitable for general circulation, but it should be available in some form for the guidance of the senior Post Office officials. We would suggest that the agreements so far reached, not all of which are contained in the Pipes Report, should be embodied in a separate document so that we may have in that one document the complete arrangements so far arrived at. It is clear, from the information that reaches us, that we are not yet anywhere near the end of the trouble. During the past year there were 23 explosions in Post Office plant. We attributed them to coal gas; but you may take a different view. However, the facts indicate that fairly frequently the thing is out of control. What happens when an explosion occurs is dependent upon luck more than upon anything else. So far as you are concerned, you are no longer in a position to deal with it. Also, in one or two places it has been very difficult to clear gas leakage from the system. We appreciate the troubles, and so far we have been very loth to take advantage of the Institution's offer to assist in those cases. But undoubtedly cases will arise in which it will be to the common advantage of both of us to take joint action and to ask the Institution to give assistance.

Points Concerning Palladium Chloride Indicator.

Mr. C. E. RICHARDS (Research Chemist, General Post Office): I should like to mention two or three small technical points with regard to the palladium chloride indicator for carbon monoxide which are perhaps not of sufficient importance to include in the description which is given in the Report. In the first place, accurate preparation of the palladium chloride liquid is a matter of first importance and it has been found necessary to specify very closely the method of preparation and the ultimate properties of that liquid. The use of liquid which is not strictly in accordance with the specification is liable to lead to seriously false results and may endanger the lives of the men who have to enter the man-holes after the test, because a small deviation from the specification might mean that the liquid is not quite reactive. The method of preparation has been carefully threshed out between the manufacturers and ourselves, and they now take very complete precautions to ensure that the fluid supplied is satisfactory.

Secondly, the indicator is intended for use with dilute gas/air mixtures, and if a test is made with it when using pure coal gas there is no darkening of the exposed test paper; the colour will change from a light buff to a greenish yellow. That is quite characteristic, and in our tests, using gas supplied at Dollis Hill Research Station, we find that the change occurs at concentrations over about 35 per cent. of coal gas in air. At concentrations below that the indicator is perfectly satisfactory. At concentrations above that there is no darkening of the centre of the paper, but there is darkening round the rim. That was found to be the explanation of a number of demonstration failures, where it was discovered that tests were being conducted in gas ovens and in improvised test chambers attached directly to gas taps. In Section II (c) of the Report of the Pipes Committee it is stated that the indicator should be suspended about half-way down the man-hole. Generally speaking, that is correct; but it should be borne in mind that in all cases tests should be made above the level of the uppermost ducts. It happens that in some cases the level of the uppermost duct is less than half-way down the man-hole; in those circumstances, of course, a test made half-way down the man-hole would be of very little use.

A. B. DENSHAM (Gas Light and Coke): The Post Office carbon monoxide detector represents a great improvement over earlier forms using palladium chloride. Engineers who have used palladium chloride in the past may have acquired a perfectly justifiable prejudice against it. The improvements in the present instrument may be summarized as follows:

(1) Small size.
(2) Simplicity and ease of use.
(3) Standard buttons are provided to compare in colour with the stain.
(4) The palladium chloride solution is made up in 75 per cent. acetone; the acetone evaporates and leaves a more or less standard dry surface which is much easier to match.

(5) Minute directions for making up the palladium chloride solution and a specification for testing it have been developed by the inventors. These are not given in the present Report. Any solution of palladium chloride which I have ever made up has invariably blackened in quite a short time, but by using very pure materials the Post Office have succeeded in preparing a solution which is quite stable for several months.

The main disadvantage of the instrument is that it is impossible to test for carbon monoxide in the presence of hydrogen sulphide, though the latter can be tested for separately. An attempt was made to remedy this by placing the detector in a glass-fronted case, and using a small bellows to blow the air to be tested through a phial of iron oxide or soda lime to remove hydrogen sulphide. Unfortunately it is necessary to have rather a large quantity of absorbent if this is not to be used up quickly, and this complication would destroy the simplicity of the instrument. It is concluded, therefore, that it is better to use the instrument as it is, and rely on more complicated methods of analysis, if, as is not often, it is essential to detect carbon monoxide in the presence of hydrogen sulphide. This disadvantage does not matter much in the case of manholes, &c., because it is equally necessary to ventilate whether there is present hydrogen sulphide or carbon monoxide.

Rubber Joint Rings for Gas Mains.

C. R. AUSTEN (Gas Light and Coke): The rubber ring joint has been known for very many years and its increasing use in this country has called for a national standard of quality which will ensure that purchasers shall be able to obtain a uniformly good quality article. The publication of the British Standard Specification for Rubber Rings for Gas Mains should do much to increase their use and to promote a feeling of security in their application and performance. Considerably large numbers of rubber joints have been used on the Continent and in America, and to a less degree in this country, and experience has shown that a well-designed joint in which the quality of the rubber is assured will give long and trouble-free service.

There is a wide dissimilarity in the composition and shape of rubber joint rings, and many Gas Undertakings and Manufacturers have their own special methods of preparing the joints. It has been possible therefore to standardize only the *quality* of the rubber used, and to cover adequately rings of different design, the specification caters for rubber rings of three distinct types, soft, medium, and hard. The tests specified necessarily involve the use of rubber testing apparatus, but they have been limited in number and severity to cover only the specific requirements of each of the three types. In the preparation of this Specification, it is felt that tribute should be paid to the Research Association of British Rubber Manufacturers who have carried out a great deal of research and have devised many of the tests specified.

Mr. Escreet Replies.

Mr. H. J. ESCREET (Chairman, Pipes Committee), replying to the discussion, said: I should like to thank Mr. Richbell for his kind remarks concerning the Report, and I will deal briefly with the points he raised. As regards co-operating with the London Passenger Transport Board, I gather that he was referring to their power cables for tramways, &c. Of course, we find that most of the power companies rather object to our opening their man-holes. We have arrangements with some companies, but the problem is rather more difficult where high tension cables and that sort of thing are involved than it is when we are dealing with telephone cables. We quite agree that if we can get some working arrangement it will be a great advantage. I note Mr. Richbell's view that the British Standard Specification for rubber rings is perhaps not so elaborate as it should be, and that he prefers some additional tests. But, as Mr. Austen has said, the specification has been based on the qualities of three different grades, and probably it should be sufficient to meet our requirements. With regard to the British Standard Specification for cast-iron pipes, it is the intention to include in it the weights of specials; but you will appreciate that a tremendous mass of figures is required. For instance, each size of T has about a dozen different sizes of outlet, so that there is a tremendous number of specials, and I think the present situation is that the specification is to be published without giving the weights, in order to avoid delay. Revision has occupied about twenty years already, so that we do not want any further delay; but the weights of specials will be included when they can be worked out. That is being done by the cast-iron pipe manufacturers, who have done a tremendous amount of work in connection with this matter. With regard to the other remarks of Mr. Richbell, whether it is desirable to specify what at present is practically a proprietary article, I am not quite certain.

I am pleased that the Post Office representatives, Mr. Barralet, Mr. Vickery, and Mr. Richards, have been able to attend this meeting. It is very good of them to spare the time, and I am much obliged to them for their remarks. I have seen the reports, mentioned by Mr. Barralet, of the tests made at Boston; they were very elaborate tests made systematically on the man-holes right round the city and were repeated after a year, I think. It occurred to me, after reading the reports, that if the man-holes in this country were such as those in Boston we should be absolutely submerged by complaints from the Post Office and from the various electricity undertakings. I do not know the conditions in Boston, but I cannot help feeling that perhaps we are already a little more particular in these matters. We get down to the problem rather sooner. Although we have not made a systematic survey of the whole of the man-holes in an area, perhaps we are dealing rather more quickly with those which require attention.

I am very glad to note the offer which has been made of co-operation with regard to electrolysis and protection, and I am sure the Committee will be very pleased to avail themselves of the information which the Post Office possesses.

It was mentioned by Mr. Vickery that there were 23 explosions in Post Office plant during the last year, and he suggested that it was a matter of luck as to whether or not these things would blow up. I am afraid I do not agree with that. It all depends on how the explosion occurs. We have not a sixth sense for locating leakage in the sealed chambers, and if an explosion is the first intimation we have of an escape it is not our fault, I feel, that we have not dealt with it in advance. But we endeavour to co-operate in every way, and although explosions may occur, we have the matter in hand, it is very difficult to find where the gas is going on every occasion; and, of course, accidents do happen.

Both Mr. Richards and Mr. Densham emphasize the importance of using the correct solution in the palladium chloride apparatus. I think I am correct in saying that the suppliers of the apparatus make up the solution to the Post Office specification, and therefore, so long as the solution is bought from the firm which supplies the indicator, we are not likely to experience any trouble in that way. It is important, however, that periodical tests should be made on the solution; if it is kept in stock for a long time it does deteriorate, I believe.

Gas Industry Co-operation.

The PRESIDENT: A question has been asked by Mr. Vickery which I should, perhaps, endeavour to answer. He asks how gas engineers are going to co-operate with the Post Office in carrying out the arrangements which have been made. Obviously it is very much easier for the people responsible at the Post Office to instruct their staffs to work in the manner indicated in Section II (*a*) of the Pipes Report than it is for us to arrange for gas engineers all over the country to co-operate. I am sure that those who have heard the discussion this morning will leave with their minds quite made up that they are going to co-operate in the most active way with the Post Office authorities, who have shown that they want to co-operate with us and help us. I can only assure Mr. Vickery that we will go into the question very carefully of finding the best method by which our members can co-operate with the Post Office.

4th Report of the Gasholder Committee

Communication No. 171

INTRODUCTION

The publication of this 4th Report marks the termination of the work of the Gasholder Committee as such. The Committee, which has met regularly since its formation as the Gasholder Construction and Deterioration Committee on 13th February, 1928, will henceforth be merged in the Gas Works Safety Rules Committee recently set up by the Council of the Institution to deal with all matters relating to Rules for the Safe Operation of Gas Works.

RECOMMENDATIONS

(*a*) *Water-scaled Gasholder Records*

The "Water-sealed Gasholder External Inspection and Maintenance Records", published as Appendix 3 to the 3rd Report of the Gasholder Committee, have been revised and are printed in their amended form as Appendix 1 to the present Report. They differ from those recommended in the 3rd Report in the elimination of Weekly and Quarterly Records, in the inclusion in the Daily Record of a note of the Adequacy of Water in Cups and Tank, and in the inclusion in the items for Yearly Record of ladders and staircases and of anti-freezing appliances.

The Gasholder Committee considers, from its experience, that the amended Records include all items of importance in connexion with the external inspection of Water-sealed Gasholders, and cover all the requirements in this respect of Clause 33 of the Factories Act, 1937.

(*b*) *Gasholder Record Sheets*

The Committee has prepared for the use of Gas Undertakings ruled and printed Record Sheets in respect of Water-sealed and Piston-type (Waterless) Gasholders, in accordance with its recommended "Water-sealed Gasholder External Inspection and Maintenance Records" (see above and Appendix 1 to this Report) and "Piston-type (Waterless) Gasholder Inspection and Maintenance Records" (see Appendix 7 to the 3rd Report of the Gasholder Committee). The keeping of Records in this standard form should be of assistance to gas engineers both for information and in connexion with visits from Factory Inspectors. Record Sheets for daily inspections of Water-sealed Gasholders are not considered necessary.

Particulars of the Record Sheets, and of standard loose-leaf binders to accommodate them, may be obtained from the Secretary of The Institution of Gas Engineers, 1, Grosvenor Place, London, S.W. 1.

(*c*) *Inspection and Insurance of Gasholders*

Inspection

The Committee desires to remind Gas Undertakings which are unable to carry out, with their own Staff, the inspections required by Clause 33 of the Factories Act, 1937, and in accordance with the recommendations of the Committee, that there exist competent firms prepared to carry out such inspections in conformity with the recommendations of the Committee.

In Appendix 4 to the 3rd Report of the Gasholder Committee a method was given for determining the thickness of sheets to ascertain if internal corrosion had taken place. This method does not involve the taking of large samples. Reduction in thickness of the sheet is the only guide as to whether the material has deteriorated. Tests made by the Committee do not indicate that there is any deterioration in the material of the sheeting during the normal working of a gasholder, and larger samples of the sheeting are not generally necessary.

Insurance

The views of the Committee regarding Insurance of Gasholders are recorded in Appendices 1 and 2 to the 3rd Report of the Gasholder Committee.

FACTORIES ACT, 1937

Since the publication of the 3rd Report of the Gasholder Committee the Factories Act, 1937, has been passed by Parliament and will come into operation, except as otherwise provided, on 1st July, 1938 or, in special cases, not later than 1st January, 1940.

Clause 33 of the Act refers specifically to water-sealed gasholders:—

"(1) Every gasholder shall be of sound construction and shall be properly maintained.

(2) Every gasholder shall be thoroughly examined externally by a competent person at least once in every period of two years, and a record containing the prescribed particulars of every such examination shall be entered in or attached to the general register.

(3) In the case of a gasholder of which any lift has been in use for more than twenty years, the internal state of the sheeting shall, within two years of the coming into operation of this section and thereafter at least once in every period of ten years, be examined by a competent person by cutting samples from the crown and sides of the holder or by other sufficient means, and all samples so cut and a report on every such examination signed by the person making it shall be kept available for inspection.

(4) A record signed by the occupier of the factory or by a responsible official authorized in that behalf showing the date of the construction, as nearly as it can be ascertained, of the oldest lift of every gasholder in the factory shall be kept available for inspection.

(5) Where there is more than one gasholder in the factory, every gasholder shall be marked in a conspicuous position with a distinguishing number or letter.

(6) No gasholder shall be repaired or demolished except under the direct supervision of a person who, by his training and experience and his knowledge of the necessary precautions against risks of explosion and of persons being overcome by gas, is competent to supervise such work.

(7) In this section the expression 'gasholder' means a water-sealed gasholder which has a storage capacity of not less than five thousand cubic feet."

As mentioned above, the requirements of this Clause in respect of External Inspection will be covered by compliance with Appendix 1 of this Report.

Other Clauses of the Act to which attention is drawn in connexion with gasholders are:—

(i) Clause 27, Precautions in places where dangerous fumes are liable to be present.

(ii) Clause 28, Precautions with respect to explosive or inflammable dust, gas, vapour or substance.

Both these Clauses make provision for the granting, by the Chief Inspector, of certificates of exemption.

GASHOLDER ACCIDENTS

(*a*) *Hamburg*

This accident, in which an aeroplane collided, in a fog, with a piston-type gasholder at a level above that of the piston, is believed to be unique. An English translation of the German report is reproduced, with the kind permission of the Hamburg Gas Company and of the Editor of "Gas- u. Wasserfach," as Appendix 2 to this Report.

The report of the accident indicates that, although a large hole was torn in the shell of the gasholder, no other serious damage was done to it, and the operation of the gasholder was not interrupted.

(*b*) *Falkirk*

The circumstances of an accident at Falkirk on 26th October, 1936, involving a two-lift, spiral-guided gasholder of 1 mill. cu.ft. capacity, were considered by the Committee.

A report kindly supplied to the Committee by Mr. H. E. Ritchie, Engineer and Manager, Burgh of Falkirk Gas Department, indicated that the gasholder was damaged during a gale, due to rollers on two of the carriages fracturing under the strain and the holder, becoming free, being buffeted about in the tank. The outer lift, which was rather less than half-full at the time of the accident, was badly holed and was not repairable. Damage was also sustained by the inner lift, guides, base plates and carriages.

(*c*) *Christiansand*

The circumstances of an accident at Christiansand, Norway, on 14th May, 1937, involving a water-sealed gasholder, were considered by the Committee.

From a brief report kindly supplied to the Committee by Mr. John Irminger, General Manager and Chief Engineer, Gas Works, Bergen, it appears that the gasholder was out of operation and was being dismantled. Insufficient care on the part of the contractors led to an explosion involving the loss of two lives.

APPENDIX 1

WATER-SEALED GASHOLDER EXTERNAL INSPECTION AND MAINTENANCE RECORDS

(Superseding Appendix 3 to the 3rd Report of the Gasholder Committee)

Name of Undertaking:
Gasholder Number:

Situation:
Purpose:
Built in: by:
Lift added in:
Type (*i.e.*, Column, Spiral or Rope Guided):
Capacity:
Lifts—Diameter and Depth of, and Pressure thrown by, each Lift:
Guide Framing—Construction:
Crown—Rise:
Sheets—Thickness of Crown Sheets:
—Thickness of Side Sheets:
Cups and Grips—Size and Construction:
Top Curb and Crown Framing—Construction:
Type of Ladder:
Tank—Diameter and Depth, and Construction:
Material used for Construction of—
(*a*) Gasholder:
(*b*) Tank:
Inlet and Outlet Connexions—Size:

Date of Inspection:
Inspection made by:

1. DAILY:

(*a*) General condition and Parts requiring attention.
(*b*) Adequacy of Water in Cups and Tank.

2. YEARLY:

(*a*) Framing:
Condition of:—
i. Columns, standards, guide rails and/or ropes.
ii. Girders.
iii. Junctions of girders and columns.
iv. Wind bracings.
v. Ladders.
vi. Paintwork.

(*b*) Lifts:
Top Lift:
i. External condition of crown sheets.
ii. Number of patches on crown sheets.
iii. Condition of ladder or staircase and handrail.
iv. Condition of carriages and rollers.
v. Cup deposits and leakage.
vi. State of roller lubrication.
vii. Condition of crown paintwork.
viii. External condition of side sheets.
ix. Number of patches on side sheets.
x. Condition of side paintwork.

Second Lift:
i. External condition of side sheets.
ii. Number of patches.
iii. Condition of ladder or staircase and handrail.
iv. External condition of cup and grip.
v. Cup deposits and leakage.
vi. Condition of carriages and rollers.
vii. State of roller lubrication.
viii. Condition of paintwork.

Third Lift:
i. External condition of side sheets.
ii. Number of patches.
iii. Condition of ladder or staircase and handrail.
iv. External condition of cup and grip.
v. Cup deposits and leakage.
vi. Condition of carriages and rollers.
vii. State of roller lubrication.
viii. Condition of paintwork.

Bottom Lift:
i. External condition of side sheets.
ii. Number of patches.
iii. Condition of ladder or staircase and handrail.
iv. External condition of cup and grip.
v. Condition of carriages and rollers.
vi. State of roller lubrication.
vii. Condition of bottom curb.
viii. Condition of bottom carriages and rollers.
ix. Condition of paintwork.

(*c*) Tank:
i. External condition of side plates.
ii. Condition at water level.
iii. Condition at ground level.
iv. Condition of ladder or staircase, handrails and platforms.
v. Level of water overflow.
vi. Tank deposits and leakage.
vii. Condition of carriages and rollers.
viii. State of roller lubrication.
ix. Condition of paintwork.

(*d*) Measurements:
i. Horizontal measurements from Lift to Lift at N., S., E., and W. points at Top Cup, Second Cup, Third Cup, and at Tank Top.
ii. Vertical measurements from top of Grip to water level at N., S., E., and W. points at Top Cup, Second Cup, Third Cup, and at Tank Top.
iii. Positions of Rollers relative to Guides on each Lift.

(*e*) Pressure:
Unusual variations in Pressure Records.
(*f*) Repairs and paintwork carried out since last Inspection:
(*g*) Condition of anti-freezing appliances:
(*h*) General:

3rd Edition.
30th September, 1937.

APPENDIX 2

REPORT OF AEROPLANE ACCIDENT INVOLVING THE PISTON-TYPE GASHOLDER AT THE TIEFSTACK GAS WORKS, HAMBURG, ON 5TH JANUARY, 1935

The following is a Translation of a Report made available to The Institution of Gas Engineers by the courtesy of the Hamburg Gas Company and forwarded to the Institution by the German Association of Gas and Water Engineers:

"On 5th January, 1935, as a result of thick fog, a sports plane collided with our M.A.N. Piston-type gasholder at a height of about 260 ft. The motor broke through two metal sheets of the holder shell. The wings and a portion of the undercarriage were cut away and fell to the ground outside the holder. The motor, petrol and oil tanks, and the remainder of the undercarriage were torn off and fell into the interior of the holder on to the movable piston which, at the time of the accident, was 110 ft. above ground level, *i.e.*, about 150 ft. below the point of collision. The rest of the aeroplane remained suspended, with its tail in the hole in the gasholder shell, so that the body, with the pilot trapped inside, projected into the interior of the holder.

"The heavy motor was thrown tangentially against the holder shell and fell about 150 ft. in a spiral, colliding about five times with the shell. It finally landed on the upper girder of the piston ring and fell from there a few feet further on to the concrete weights on the piston cover, 16 ft. from the edge of the piston. The full petrol and oil tanks followed a similar path, their contents being emptied partly on the holder shell and partly on the piston. A quantity of wood and metal fragments of the aeroplane, including the two magnetos, together with splinters of the holder shell, fell into the sealing trough of the piston.

"The interior of the holder was inspected a few minutes after the accident and it was found that the piston was undamaged and that the seal was functioning perfectly. The operation of the holder was at first unaffected. All the engineers and works hands concerned immediately concentrated upon the control of the holder, the measuring and control instruments in particular being kept under continuous observation.

"The fire brigade, to whom the alarm had also been given, commenced by securing the tail of the aeroplane, which projected from the point of collision, in order to prevent the threatened fall of the body of the plane.

Several firemen then climbed out from the middle of the roof girders to above the point of the accident, about 70 ft. below, and let down ropes. One man climbed through the hole in the holder shell, fastened himself to one of the ropes and, suspended in mid-air, secured the body of the aeroplane with the other ropes. The body was then further supported, in the same way, by passing under it a sheet also suspended from the roof girders. Not until then, after four hours of extremely dangerous work, was it possible to release the severely injured but still living pilot, who was fastened with a rope, rescued through the hole made by the collision and transferred to hospital. As no danger existed and the interior of the holder was becoming dark, the clearing up work of the fire brigade was suspended.

"Although the sealing trough of the piston had been examined a considerable drainage of sealing liquid was observed at 6.30 p.m. Immediate investigation revealed an abnormally low level of the liquid in the sealing trough. All pumps were immediately started and operated continuously and satisfactorily; at the same time, however, in order to ensure the more rapid raising of the liquid level, four of the 14 reserve tanks were opened. With the assistance of a rescue squad of the fire brigade the piston was again examined, oxygen apparatus being first used for safety until it was established that the air above the piston was uncontaminated. The examination showed that the rapid draining of the oil was caused by some pieces of wood which, during the rising of the piston, had become wedged between the edge of the trough and the shell of the holder whereby the former was forced slightly away from the latter. These disturbances having been removed, the holder again worked satisfactorily.

"A second disturbance, of a similar nature but of less importance and which was equally speedily rectified, occurred some hours later, at about 2 a.m. Daylight revealed that in this case the trouble was due to the two broken magnetos, which had fallen into the trough and the cables of which had come between the edge of the trough and the shell of the holder.

"At the first disturbance the fire brigade installed an emergency post alongside the holder.

"At about 9 a.m. on 6th January the fire brigade resumed its clearing up operations and, after three hours' work, lowered the body of the aeroplane on to the piston. At 10 a.m. three representatives of the constructional firm, M.A.N.-Gustavsburg, arrived at Tiefstack and immediately made a fresh examination in which they tested, in particular, the trough seal three times for any defect. A considerable number of foreign bodies, particularly parts of the motor, were removed from the trough.

"The following is a summary of the technical findings:

1. The hole at the point of collision was 5¼ ft. high by 10 ft. long.
2. Two outside sheets were completely destroyed.
3. Four outside sheets at the point of collision were considerably deformed at their edges.
4. Three sheets had more or less considerable indentations, caused by the motor falling against the shell, and the upper girder of the piston ring was considerably deformed at one point.
5. The connexions of the diagonal stays were partially loosened, and some of the diagonal stays were bent.

"The repairs to the holder took about three weeks. The stability and operating capacity of the holder were in no way endangered since, until the repairs were completed, the piston was not allowed to rise above the level corresponding to a content of 4¼ mill. cu.ft.

"The previous arrangements for the supervision of the holder and the precautions hitherto observed in operating the holder proved entirely adequate and appropriate, even in the above difficult circumstances, and the holder has functioned completely satisfactorily, except for the two disturbances referred to above.

"The stricter supervision mentioned above was, of course, continued day and night for a short period."

7th January, 1935.

Discussion.

Colonel W. H. Carr, O.B.E.: It is announced that this Report is the last Report by the Gasholder Committee. As a matter of policy for the time being, and I hope it may be only for the time being, the Gasholder Committee is to be merged into the Gas-Works Safety Rules Committee. I feel that in the future the Institution will have to do some work in the way of the collection of information relative to the construction and factors of safety of holders of different types. During the last six months there has been a considerable amount of controversy in the Technical Press as to the relative merits of welded and riveted holders. Arguments have been advanced on both sides. Investigations as to the merits, and as to the tests that should be made to ascertain those merits, insofar as factors of safety are concerned, could not be done better than by a Committee of this Institution; therefore, I hope we have not lost the Gasholder Committee and that its work may be merely suspended for the time being. We as an Institution appreciate the work that has been done by the Committee and by its Chairmen in the past; it has rendered very useful service and I for one feel that there is still a considerable amount of very valuable work for it to do, though perhaps not on the same lines, inasmuch as the maintenance question has now been dealt with definitely. There are other investigations which might well be carried out, with the co-operation of our members who are directly interested in the construction of holders.

Perhaps I may digress for a moment in considering the best method of carrying out inspections in conformity with the recommendations of the Committee. It is comparatively easy for the large holding company with which I am connected, for example, because by reason of the large number of holders we have to-day there is full-time work for an inspector in inspecting the undertakings which are constituents of the holding company. Small undertakings have the alternatives of employing gasholder contractors and insurance companies, and it has been mentioned to me that there is a possibility that Lloyd's Register might be interested in engaging in that class of work for gas undertakings. But the point I wish to make is that, irrespective of what is decided upon, it behoves us all to remember that our own responsibility is not in any shape or form lessened by the Factory Act and by the fact that we are subject to inspection under that Act. I hope it will bring home to us all the necessity at all times of maintaining the daily routine without failure.

Mr. G. C. Pearson (Birmingham): We have recognized for some years in Birmingham the desirability for the skilled supervision of the working of gasholders, and as a matter of fact we have been able to make comments on the programme produced by the Institution in this 4th Report of the Gasholder Committee; so that I have very little to offer on the procedure suggested. It is interesting to note, however, that we appointed a gasholder examiner in Birmingham 4½ years ago and provided him with an adequate staff for the maintenance and supervision of gasholders. He carried out all the adjustments required, and also minor repairs to large holders, in the case of holders of 250,000 cu.ft. or less capacity, of which we have a number. The system of examination we adopt is very similar to that of the Institution and has worked smoothly. We have the very great advantage that we know that our holders are in good condition, that any necessary adjustments are carried out, and that if any major repairs are needed in due course we can prepare a programme with exact knowledge of the condition of the holders.

I think that an ordinary handy-man ought to understand the rules and regulations drawn up in the 4th Report of the Gasholder Committee, and there ought to be no difficulty in applying them to any undertaking. The only addition that I can suggest to this programme of instructions is that there should be, at long periods probably, a tangential plumbing of the gasholder columns. I mention that because we are repairing a 10 million cu.ft. holder at the present time and we find that the tangential plumbing is considerably out. How that has come about I do not know; probably there was a fault in the first instance. But the worst columns are 2½ in. out of plumb and they have to be brought upright. It seems to me that tangential plumbing might be included, say, once in fifteen or twenty years.

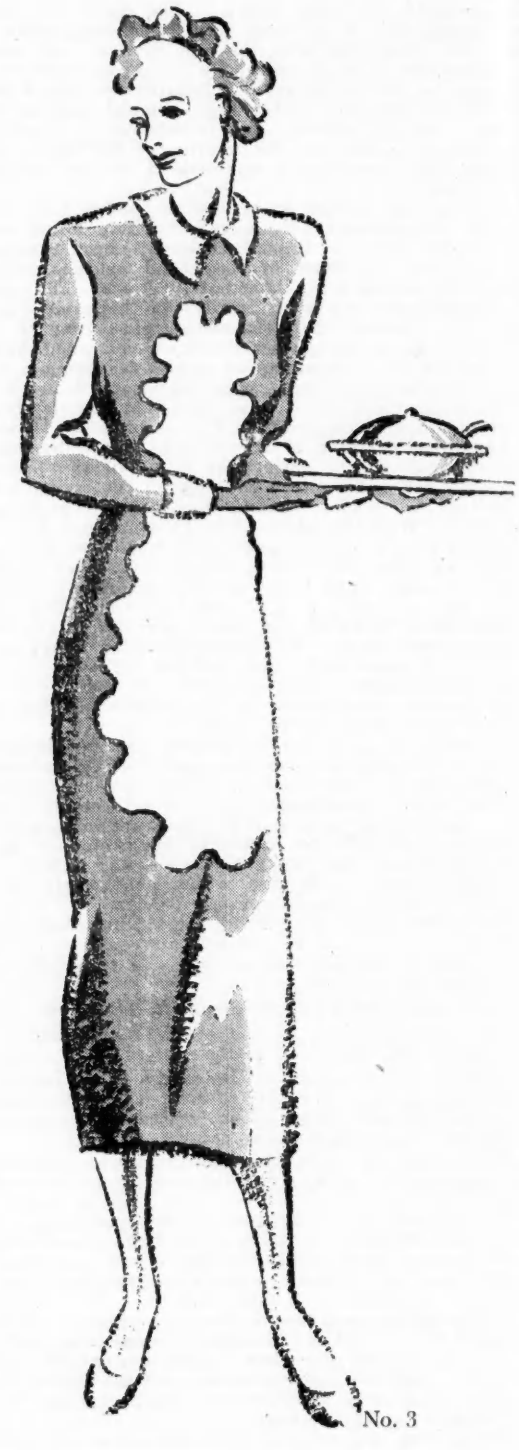
Examination of Water-Sealed Gasholders.

Mr. A. L. Holton (Manchester): I should like to make a plea that those of us who have to deal with circumstances that are of peculiar interest in the working of our gasholders should submit the facts to what is now the Safety Rules Committee. A collection of such information would be of great value.

I wish to make reference to the Rules which it is suggested should be observed in the examination of our water-sealed holders. It is stated that when the manhole cover has been taken off, a cage of mice should be lowered into the holder to ensure that the conditions are such that the men can safely enter. I wish to make a very strong plea because of circumstances which I have observed, that where men are working on a raft the cage of mice should not merely be lowered and then withdrawn, on the assumption that because the mice have been exposed to the conditions for a certain length of time without harm, those conditions are such that the men can enter. The cage of mice should be on the raft with the men the whole time those men are

Service for Comfort

RADIANT-PANEL
GAS HEATER



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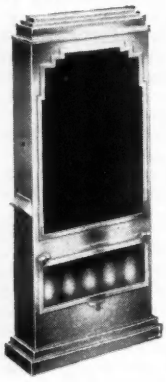

No. 11

I knew she'd like a
RADIANT-PANEL
GAS HEATER
The Secret is the Plain Black Panel

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working. Not only does hot weather render conditions unpleasant for working in the holder, but you will find also that the heat is likely to give rise to various gases and that the low level of the water line can be very detrimental.

I should also like to suggest that in the Reports that we make we should have a little more information as to how to deal with the condition of the bottom curb and of the bottom carriages and rollers. If the tank is empty, the problem is easy, but if these things are submerged the examination must, of course, be somewhat restricted. I would suggest to the Committee that they emphasize a little more, and possibly in greater detail, the examination of the grips and the cup.

Factories Acts' Requirements Quite Reasonable.

Mr. G. M. GILL: I have looked through the 4th Report of the Gasholder Committee with a great deal of interest and I note that in future the Gasholder Committee is to be merged in the Gas-Works Safety Rules Committee. I think that will be a very good innovation if it does not mean that they will discontinue the very useful work they have been doing on gasholders, because gasholders will need a lot of attention for some time to come and members require the kind of help that the Committee can give them. I have noticed that the work of the Gasholder Committee has undoubtedly been effective in drawing much needed attention to the whole question. The schedule setting out the type of examination which should be made is excellent. I have considered it item by item and cannot suggest any alterations; I think it covers the whole ground. It is important, of course, that the results of the inspection should be set out in writing. As Mr. Hardie has said, the requirements of the Factories Act are not at all onerous; in my opinion they are quite reasonable and will result in much needed attention being given to certain holders which have been neglected.

The Committee's Reports have also given a fillip to the taking of specimens from sheeting; that work has resulted in the design of several very excellent tools for the purpose, so that it is now a very simple matter to take specimens of sheeting. The visual examination of those specimens can be very useful and very interesting, and it gives a very good idea of the condition of the sheeting of the holder. Sometimes, when making examinations, one is quite surprised by the condition of the sheeting. I was a little surprised to note from the Report that the Committee consider that fatigue of the metal is not the important factor that some of us thought it was, and I am inclined to think that the Committee are quite right in the view they express. The internal examination of holders while they are being inflated is, I suppose, an innovation, and it is a very useful innovation. During the past few weeks I have been concerned with two holders which have been inflated with air, and which have been examined as the bell rose. A very good examination can be made in that way. In my experience I have found the welding process most useful in the repair of gasholders. Quite a number of gasholders with which I am concerned have been extensively repaired while in use by welding.

Record Sheet Preparation.

Mr. E. B. TOMLINSON: It may be considered that in the Report there is not very much that is new, but during the last year our time has been spent largely, as already explained, in the preparation of the record sheets, as the result of suggestions made by Mr. Robertson at the last Autumn Research Meeting. Those sheets make provision for recording the particulars of examinations normally required for the safe working of gasholders, and also provide suitable forms of reports which will meet the requirements of Clause 33 of the 1937 Factories Act. Naturally, the record sheets have to be drafted to suit the largest gasholders. At the same time, they are quite suitable for recording the particulars of small ones. While the record sheets, if properly filled in, will meet all ordinary requirements, it does not follow, of course, that the engineer whose ordinary records reveal that a gasholder is in an unsatisfactory state will not require further detailed examination, the results of which can be recorded either on sheet 6 or on the supplemental sheet 1a, or even on the backs of some of the other record sheets. An instance of that is the case referred to by Mr. Pearson, where he found that the tangential plumbing of the guides was somewhat out, and therefore would need examination.

Mr. F. M. BIRKS: I should like to say how extremely sorry all my colleagues on the Committee and myself were that Mr. Hardie could not be persuaded to accept the Chairmanship of the new Committee which is being formed. I need hardly say that, although I shall do my best, I shall never be able to attain the standard which Mr. Hardie attained in the Gasholder Committee.

A number of people have telephoned me with regard to the small disc-cutting device; some people seem to have found certain difficulties in using it. If anyone has any difficulties in matters such as this at any time, I shall always be very pleased to give any information.

The PRESIDENT: At the conclusion of this afternoon's session we have to express our thanks to a large number of people and bodies, but I think we ought to pass a special vote of thanks now to Mr. Hardie and the Gasholder Committee. The work of the Committee has been finished for the time being and all the members, with the exception of Mr. Hardie, have joined another Committee dealing with Safety Rules. I am sure we all wish to propose a very hearty vote of thanks to the Gasholder Committee, and I know the members of that Committee would wish that due thanks be accorded Mr. Hardie for the very important work that has been done during the last few years.

The vote of thanks was carried with enthusiasm.

Mr. THOMAS HARDIE: I thank you very much for the kind way in which this vote of thanks has been proposed and accorded. It has been very pleasant work as Chairman of the Committee because all the members of that Committee have been very kind and all of them have been most anxious to give their considered opinion for the benefit of the members of the Institution as a whole. I think you will find that the results of their work should be very useful to you in determining the lines to take in respect of the requirements of the new Act.

Purging Gasholders by Means of Inert Gas

By F. M. BIRKS, O.B.E.,

Deputy Chief Engineer, Gas Light and Coke Company

Communication No. 172

The Inert Gas Purging Machine used in the work described in this Paper was evolved by C. A. Harrison, of the Brooklyn Union Gas Company, having been developed as a specialized portable machine as distinct from fixed units in connexion with the use of water gas, internal combustion engine exhaust gas, waste flue gases, and the like, which were mentioned by Herbert W. Alrich, of the Consolidated Gas Company, New York, in his Paper* to the American Gas Association in 1932.

The machine was introduced into this country in 1934 and the first one was installed at the Stepney Works of the Commercial Gas Company, where it is connected to a permanent inert gas main. Connexions to this main enabled purifiers and other plant, such as gasholders, to be purged as required: the purging of purifiers at Stepney is a matter of routine whenever a box is opened. The results obtained with this plant were described by A. S. Lee in an unpublished communication to the Southern Association of Gas Engineers and Managers (Eastern Section) in March, 1937.

Early in 1936 the Gas Light and Coke Company took delivery of a similar but larger and improved machine, rated at 35,000 cu.ft. of inert gas per hr. It was first used to purge two gasholders that were being put out of commission at Vincent Street Holder Station and has been regularly employed since then.

Briefly, the machine consists of a water-cooled cylindrical refractory-lined combustion chamber, at one end of which a burner is fitted. Gas and air are supplied to the burner under pressure by two Connersville pumps driven by a gas engine. By the provision of valves by-passing the blowers and of quadrant cocks on the supplies to the burner it is possible to get very sensitive control of the ratio of gas to air, and the attainment of a nearly perfect waste gas is simple.

THE PURGING PROCESS

The holder can be purged either landed or floating, as the machine is capable of producing pressures up to 50 in.

* Proc. Amer. Gas Assoc., 1932, 826.

TABLE 1.—*Purging Analyses.*

Plant Purged.	Date.	Amount of Gas to be Displaced, Cu.Ft.	Amount of Inert Gas Used, Cu.Ft.	Ratio of Inert Gas to Gas Displaced.	Temperature, ° F.		Analysis (by Orsat) of Inert Gas Leaving Purging Machine. Per Cent.			Analysis of Gas Leaving Holder Crown at End of Purge. Per Cent.		
					Gas Leaving Purging Machine.	Gas Entering Holder Inlet Main.	CO_2.	O_2.	CO.	CO_2.	O_2.	CO.
1	2	3	4	5	6	7	8	9	10	11	12	13
No. 3 Holder, Vincent Street ..	5.5.36.	151,600	307,700	2·03	100	86	11·4	0·2	0·3	10·0	—	—
No. 4 Holder, Vincent Street ..	21.5.36.	61,500	138,600	2·25	129	—	10·4	0·8	0·4	10·2	—	—
No. 1 Holder, Harrow ..	18.6.37.	17,040	39,400	2·31	147	145	10·3	0·8	0·3	10·5	0·0	0·3
		Amount of Air to be Displaced, Cu.Ft.		Ratio of Inert Gas to Air Displaced.								
No. 2 Holder, Beckton ..	2.9.37.	89,000	295,500	3·32	180	—	10·4	—	—	9·5	—	—

w.g., any excessive pressure being controlled by the inert gas relief valve.

The advantage of purging with the holder floating is that in the event of an inadvertent stoppage of the engine, the holder vent valve can be closed with no fear of a vacuum forming in the bell.

A differential seal is provided to prevent the contents of a floating holder being forced back into the hot combustion chamber should the engine fail.

The method of purging gasholders which has been adopted is to introduce the inert gas through the inlet main, simultaneously allowing the gas in the holder to escape through the vent valve situated near the centre of the crown; the escaping gas is conducted by canvas and light metallic tubing to some safe point well above ground level.

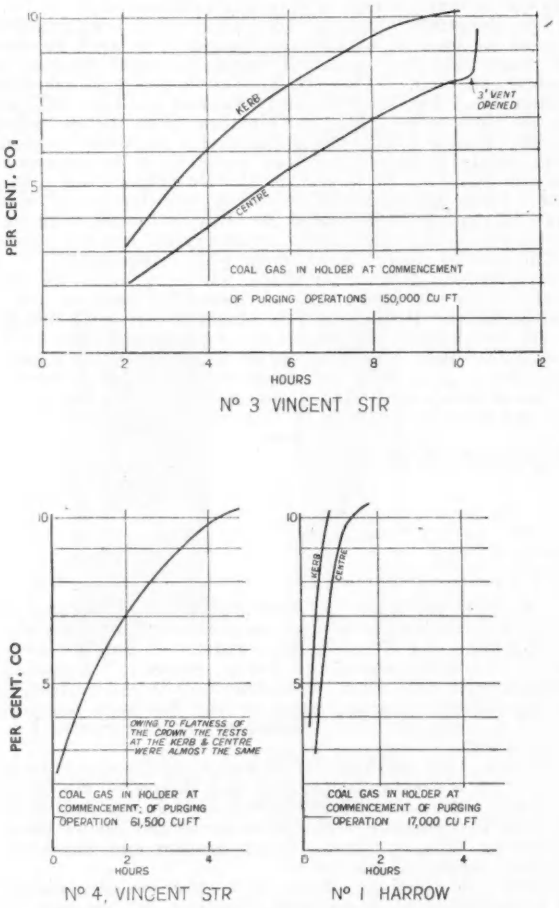

PER CENT. CO₂
HOURS
KERB
CENTRE
3" VENT OPENED
COAL GAS IN HOLDER AT COMMENCEMENT OF PURGING OPERATIONS 150,000 CU FT
Nº 3 VINCENT STR
PER CENT. CO
OWING TO FLATNESS OF THE CROWN THE TESTS AT THE KERB & CENTRE WERE ALMOST THE SAME
COAL GAS IN HOLDER AT COMMENCEMENT OF PURGING OPERATION 61,500 CU FT
COAL GAS IN HOLDER AT COMMENCEMENT OF PURGING OPERATION 17,000 CU FT
Nº 4, VINCENT STR
Nº 1 HARROW

FIGURE 1.—*Analyses of Gas leaving Holders.*

The results obtained in each case are summarized in Table 1, and curves showing the analysis of the gas leaving the holder are given in Figure 1.

In addition to the figures given in Table 1, a complete analysis of the inert gas shows that the amount of combustibles is negligible, the percentage composition being:

CO_2	10·7
O_2	0·6
C_2H_m	0·2
CO	0·3
CH_4	0·0
H_2	0·0
N_2	88·2

Gas and Water Consumption

The gas consumption, including that required for power, is approximately 8,500 cu.ft. per hr. with an output of 35,000 cu.ft. of inert gas per hr.

The amount of cooling water used is large; tests carried out prior to the use of the machine at Vincent Street showed that about 10,000 gal. per hr. were required. Part of the cooling is done by sprays, and it is essential to use clean water for this in order to keep the sprays clear. The amount of water used on the sprays is sufficient to ensure saturation of the gas when it leaves the machine. The larger proportion of the water is used to cool the combustion chamber, and for this purpose the gasholder tank water is a convenient source of supply.

It will be noted in Table 1 that in two instances, *i.e.*, at Harrow and Beckton, the temperature of the inert gas leaving the machine was high, 147° F. and 180° F.: this was due to the inadequate volume of water available. The supply was metered at Harrow, and it was found that 6,000 gal. per hr. were used.

Inert Gas Purge

It will be seen from Table 1 that the amount of inert gas required to purge a holder of gas is just about twice the volume of the gas in the vessel. This agrees with the findings of users of similar plants in the United States of America.

The necessity for using the excess of inert gas arises from the diffusion of the two gases within the holder. The actual amount of diffusion will depend upon (*a*) relative densities of the two gases, (*b*) relative temperatures, (*c*) mechanical movement. Items (*a*) and (*b*) are interrelated in that an increase in temperature results in a reduction in density or vice versa: temperature differences will also give rise to mixing by convection.

The specific gravity (air=1) of the inert gas was found to be 1·07. It is therefore just over twice as heavy as the gas normally supplied by the Company. The effect of the temperature of the inert gas leaving the machine would be to reduce the density by about 15 per cent., but measurements made of the temperature of the gases in the holder itself showed that rapid cooling took place during the passage of the inert gas into the holder. The figures obtained are given in Table 2.

TABLE 2.—*Temperatures of Gas in Holder.*

Time.	Fraction of Purge Completed.	Temperature, ° F.				
		At Inlet of Holder Inlet Main.	Immediately under Crown.	3 Ft. above Water Level.	Immediately above Water Level.	Atmospheric Temperature.
1	2	3	4	5	6	7
11.35 a.m.	0·23	145	72	73	74	—
12.05 p.m.	0·55	145	73	—	82	59

The velocity of the inert gas issuing from the inlet pipe

also tends to bring about a certain degree of mixing and is the chief factor under section (*c*) referred to above.

The purge is considered complete when the contents of the holder crown are non-inflammable when mixed in any proportion with air.

A consideration of the limits of inflammability of the several constituents of coal gas leads to the conclusions given in Table 3.

TABLE 3.—*Proportion of Inert Gas required for the Production of Non-Inflammable Mixtures.*

Inflammable Gas.	Volumes of Inert Gas per Volume of Inflammable Gas to form Non-Inflammable Mixture.	CO_2 in the Non-inflammable Mixture Formed, Per Cent.
1	2	3
Hydrogen	15·4	10·4
50 per cent. hydrogen, 50 „ methane	10·4	10·1
50 „ hydrogen, 50 „ carbon monoxide (water gas)	10·0	10·0
Town gas (G.L.C.C.)	10·1	10·2

The purging operation has therefore to be continued until the gas issuing from the crown vents is a mixture of 1 part of town gas, with at least 10 parts of inert gas.

The most practicable method of control is to purge until the CO_2 content of the escaping gas is at least 91 per cent. of the sum of the mean CO_2 content of the purging gas (on an air-free basis) and one-tenth of the CO_2 content of the gas initially in the holder.

Thus if the purging gas and the initial gas in the holder contain 11 per cent. and 3 per cent. respectively of CO_2, purging must be continued until the CO_2 in the mixture is above 0·91 (11 + 0·3) = 10·3 per cent.

The non-inflammability of the gas is usually checked by collecting a sample in a suitable vessel and attempting to ignite it in the laboratory or some other convenient spot.

Air Purge

The inert gas purge is immediately followed by an air purge which is continued until the holder is fit to be entered. In determining this, the concentrations of hydrogen cyanide, hydrogen sulphide and carbon monoxide in the holder atmosphere should be considered.

The toxic limits for carbon monoxide and hydrogen cyanide are given in the following table, together with the effect at various concentrations in a holder atmosphere.

TABLE 4.—*Toxic Limits for Carbon Monoxide and Hydrogen Cyanide.**

——	CO, Per Cent.	HCN, Per Cent.
1	2	3
Fatal in ½ hr. or less	0·5 to 1·0	0·048
Causing dangerous illness in ½ to 1 hr.	0·2 to 0·3	0·012 to 0·024
Endurable without serious effect for ½ to 1 hr.	0·05 to 0·10	0·005 to 0·006
Maximum safe concentration	0·04	0·002 to 0·004

* International Critical Tables **2**, 318.

When a holder is put back into use after inspection or repairs, the air contained in the crown has to be displaced

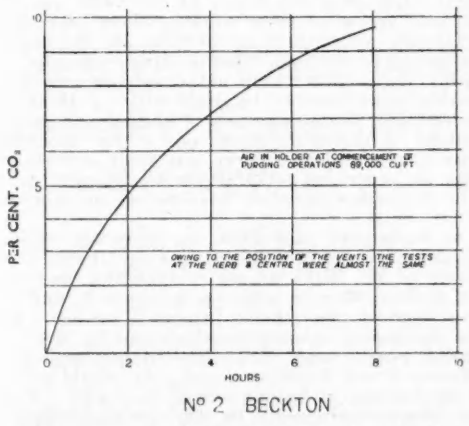


FIGURE 2.—*Analysis of Air leaving Holder.*

by inert gas before town gas is introduced. As the densities of inert gas and of air are very similar, the piston-like effect obtained when inert gas is used to displace town gas is much reduced when air is replaced by inert gas. It has been found that the amount of inert gas required in such cases is from 3 to 3½ times the volume of the air that has to be displaced.

The analysis of the air leaving the holder during an operation of this nature is shown in Figure 2.

Gum Formation

As a matter of interest, the use of inert gas has confirmed how gum is formed by nitric oxide. During the purging operations it was found that the inert gas contained up to 67 parts of nitric oxide per mill. The nitric oxide reacted with the gum-forming hydrocarbons in the gas in the holder and the issuing gas contained a considerable amount of gum. The gum was measured by means of the thermal precipitator and a maximum count of 2,700 particles of 0·8 μ diameter per c.c. was noted. This figure corresponds with a concentration of approximately 200 grains per mill. cu.ft. (The gas in the holder was free from gum before purging.)

COSTS

It is difficult to generalize with regard to the cost of purging with the inert gas plant, but if this is of such character that air blowing plant is necessary the only cost additional to that normally incurred is of the transport of the purging machine and the provision of the necessary gas and water connexions, the cost of which will, of course, depend upon local conditions.

The operating costs in themselves are low. The cost of inert gas is about 8d. per 1,000 cu.ft. with town gas at 2s. per 1,000 cu.ft. dependent to some extent upon the cost of water. The operating costs amount to between £2 and £10 per holder, dependent on its size. As an example, the cost of purging a holder by the usual means and by the purging plant has been estimated, and the approximate increase in cost is some £50. With a medium or large-sized holder this £50 represents a small proportion of the whole cost of carrying out an internal inspection and repair.

The machine has also been used to purge gasholders other than those quoted and also to enable difficult welding operations to be performed. In one case a long length of overhead steel gas main had partially failed at the welded joints; a complete repair was effected by welding mild steel strips over the joints while the main was kept under a slight pressure of inert gas.

The machine is also being used to inflate a water gas relief holder with inert gas while extensive repairs are being undertaken by means of welding.

No difficulty has been experienced in operating the machine, but it has been found to be somewhat cumbersome, and it is proposed in the near future to split it into two or more sections in order to make it more easily portable.

Discussion.

Mr. THOMAS HARDIE: You will have noticed that in the 4th Report of the Gasholder Committee there is a reference to purging and to Mr. Birks' Paper, but the Report contains no recommendation as to purging, because the Committee did not think it was necessary in most cases. In Mr. Birks' Paper there is described a simple method by which we can be 100 per cent. safe in either clearing a gasholder or re-charging it with gas. In most cases ordinary precautions are quite sufficient when we want to clear a holder of gas. But some holders are very badly situated; there may be property adjoining, in which case it is very difficult to control what takes place, and the Committee certainly recommend that under those circumstances the use of the method described by Mr. Birks for clearing the holders should be carefully considered.

Desirability of Purging.

Mr. G. C. PEARSON (Birmingham): We cannot overemphasize the desirability of purging gasholders by means of inert gas. During the operation of purging a gasholder by air the holder is at certain times a potential danger of such terrifying magnitude that any amount of trouble is worth taking to eliminate that possibility. I should like to relate an incident which came to my notice. I was talking to a man who was responsible for the purging of a 6½ million cu.ft. holder situated adjacent to a railway goods yard, and at one point the railway lines were within 30 ft. of the holder. Of course, arrangements were made with the railway company to ensure that those lines were not used during the afternoon on which the purging was carried out. But there were locomotives at work probably 250 to 300 yd. away while the purging operation was carried on. After purging had commenced, a man standing on the top of the holder was able to see the small clouds of gas flickering alight above the locomotives. Given the right conditions of distance and calmness of the atmo-

sphere, such flames could come back to the holder, and only a little disorganization of the arrangements whereby the lines in the immediate vicinity of the holder were not used might give rise to a terrible disaster, for the holder is a big one, and it is surrounded by property.

Recently one of our young men, Mr. Bengough, read a Paper to the Midland Junior Gas Association on the purging of gasholders, and described the use of a home-made plant at the Nechells Gas Works. He pointed out that he was using the same quantity of water as Mr. Birks uses, but that the temperature of the inert gas was very much lower than that used by Mr. Birks. There is no doubt that the temperature of the inert gas used by Mr. Birks was rather on the high side and might cause difficulty if the purging plant had to be stopped at any time. On the other hand, the purging plant described by Mr. Birks is truly portable, whereas the plant at Nechells is not, although every care and thought was devoted to making it so. That question of portability is very important. I think it would be a simple matter for Mr. Birks to include extra cooling capacity on another trolley.

New Era of Safety in Gas Works Practice.

Mr. E. G. STEWART (Gas Light and Coke): Because an explosion of gas is so rare an occurrence on a gas works, it is possible for the gas engineer to spend many years in the practice of his profession without personal experience of one. Additions to traditional practice, therefore, are apt to be considered somewhat academic, or at least superfluous.

Let us then remind ourselves of the Holborn explosion of nine years ago, when half a mile of soundly constructed London road was blown up and damage to the tune of £140,000 resulted. The total volume of explosive mixture involved was about 40,000 cu.ft., and if town gas had been the cause, only 3,000 cu.ft. would have been required to cause the mischief. These volumes are of the order of those involved in putting gasholders, purifying plant, and new lines of mains into or out of use. This Paper by Mr. Birks is therefore timely, and deserves the closest attention of all of us responsible for operations where mixtures of gas and air are encountered. In 1931 I was in the United States, and I particularly noticed that at every works I visited, the practice of purging with inert gas any mains, plant, holders, &c., which had contained gas and were being put out of commission for repairs, alterations or rest was the standard procedure, and, similarly, of course, for the reverse operation. The only exception at that time appeared to be in the case of purifiers, but here steam was always used to displace pockets of gas. At one works CO_2 in cylinders was used as a purging medium. It is necessary in that case to earth the cylinders, otherwise an electrostatic discharge may arise. In another the exhaust gases of petrol engines were used. Elsewhere fans and pipe lines around the works delivered boiler flue gases for the purpose. At Brooklyn I was fortunate in being able to inspect the first model of the tool so ably described in the Paper. The advantages claimed for the method were portability, high quality of inert gas, and suitability wherever supplies of gas and water were available. No changes have since been made in principle, and it remains substantially as originally developed. It is not, therefore, an experimental piece of apparatus we are being invited to adopt, although the Author has some suggestions for its improvement.

Purging opens up a new era to the gas engineer. The putting in and out of service of gasholders and similar plant can be performed with its aid with an absolute elimination of hazard in the most densely occupied areas. Operations involving welding can be extended to fields where hitherto it would have been dangerous to introduce a flame. Fire in closed vessels, such as oil tanks, purifiers and the like, can be easily controlled, while finally the engineer who has once employed purging will, I am certain, extend the use of it to more and more operations on gas apparatus.

The cost is small when peace of mind alone is considered; from the point of view of an insurance premium it is absurdly low. These remarks must not be construed as an unqualified recommendation of the machine as a panacea. The simple but necessary check gas analyses described in the Paper must be carried out, and the tool used at all times with understanding. Furthermore, it must be remembered that an atmosphere of inert gas which is later contaminated by benzole or oil vapour, is not necessarily immune from explosion if mixed with air and fired. Nevertheless, intelligent application of purging should mark the commencement of a new standard of safety in gas practice.

Slightly Different Procedure.

Mr. A. E. WILLIAMS (Commercial Gas Company): After three years' experience of the Harrison machine, I believe it is only a question of time for some form of apparatus for the production of inert gas to be included in the standard equipment of all the larger undertakings. In 1934, when I decided to adopt the Harrison machine, I had in mind two principal objects. The first was to eliminate as far as possible the risk of explosion in the old-fashioned and rather badly ventilated purifying house at my Company's Stepney works by purging each box before the cover was lifted. The second was to have at my disposal some means of emptying gasholders without forming an explosive mixture. The latter consideration seemed to me to be of very great importance when dealing with old holders which have been rather badly contaminated with sulphuretted hydrogen, and which are, therefore, very likely to have a deposit of iron sulphide on the interior of the sheeting. When we started to use the machine we found it desirable to make certain additions. We had to increase considerably the provision for cooling the gas, and at present we are able to reduce the temperature to 120° F. We also substituted quick-acting valves and relief valves on the gas and air supplies for the screw-down valves originally provided, and we fitted a water seal which served the double purpose of isolating the machine from the part which was being purged and also helped in the cooling of the gases. With those modifications we have found the machine to be very easy to control. It produces inert gas of very constant composition, which in our experience can be kept within considerably narrower limits than those mentioned in the Paper. I can confirm everything that previous speakers have said about the various uses to which the machine can be put. In our own case it has fulfilled admirably the two purposes for which it was primarily installed, and in addition I have found it most useful from time to time for displacing gas or air from lengths of main and various pieces of gas works plant.

Our procedure for emptying holders has differed slightly from that described in the Paper. It has been our practice to admit sufficient inert gas with the vents closed to lift the holder three or four plates, then to shut off the inert gas and blow away through the vents. By repeating that process three or four times we get down to the required composition; also, we think it reduces to a minimum the amount of mixture which takes place in the holder and the proportion of inert gas that is required.

Estimating the proportion of inert gas in the mixture by means of the CO_2 content is quite a reliable method when dealing with gasholders, but we have found by experience that with purifiers and other vessels, where ammonia may be present, the CO_2 is affected by reactions and one is apt to get misleading results. Therefore, we have adopted the practice of using the carbon monoxide content as the basis for our estimates.

Machines Available for Hire.

Mr. D. M. HENSHAW: In the case of new plant, users often gain very much more knowledge of it in a comparatively short time than the makers themselves, because often the makers, having constructed a plant, have little opportunity of securing knowledge of its operation. At the same time, Mr. Birks has given a good deal of thought to this machine and has put in a good deal of work on it, and we are very pleased to co-operate with him, not only in simplifying it, but in making its operation more easy and more applicable, in the widest possible way, to various operations on gas works. The machines which have been described to-day—there are six of them in use in this country, I think—are more or less of the standard pattern adopted in America when the Harrison purging machine was first built there about four or five years ago. Now I think there are 46 of them working there, not all in gas undertakings, although many of them are the property of the larger undertakings. The machines are also used in oil works and in other such industrial concerns where inflammable gases have to be dealt with. I think, as Mr. Birks has said, the recognition of the advantage of using a machine of this kind arises out of the fact that the Americans often like to carry out their operations very rapidly; in order to get through the danger period as quickly as possible they are glad to use machines of this kind.

It is recognized that these machines are of necessity rather unwieldy and are difficult to move about. With the assistance of Mr. Birks we are re-designing them with the idea of making them a little more compact, and possibly putting them on two vehicles instead of on one. Further, we are developing a machine which can be hired. There are many people who would like to use such machines at different times of the year, but who would not care to go to the expense of buying one of their own. Therefore, I think that machines will be made available for hire for short periods; and, of course, such machines must be made as transportable as possible.

Factors to be Observed.

Mr. T. F. E. RHEAD (Birmingham): The process described in the Paper is very long overdue in this country.

We chemists are not particularly nervous people as regards the purging of gasholders, but we have no moral right nowadays to take risks such as have been taken in the past in connection with gasholders situated in the middle of congested areas. I need not stress the need for the plant described, because apparently I am talking to the converted. The Americans were brought to it by the very serious Pittsburg disaster. Incidentally at Billingham purifiers and such like plant are purged with nitrogen from the synthetic ammonia plant.

It is essential, of course, that an inert-gas-purging plant should be both correctly designed and used; otherwise the users will be lulled into a false sense of security and they might introduce more difficulties than they eliminate by its use. That is an extremely important matter. I have been looking for all the snags in connection with this matter, and I am very much impressed by the need for observing certain points. The plant in its present stage does embody the results of very searching enquiries made in America into the whole question. In connection with purging we might classify the grouped factors which have to be observed as (1) atmospheric conditions; (2) the sources of ignition (we have already heard a reference to what might happen due to the proximity of a railway siding to a gasholder); (3) positional factors (Is the plant to be near the holders or at a distance?); (4) the design of the purger itself; and (5) the method of its control.

As to the plant itself, I consider that " knife-edge " control of gas and air is necessary. By means of suitable valves the gas and air can be controlled perfectly, so that, once the machine is set, the composition should not vary. There must not be any failure in the supply of either gas or air; preferably they should be coupled to the same drive so that if the supply of one is stopped the supply of the other is stopped also. We do not want air or gas going forward separately without knowing about it, for if that happened we should be running risks which are, to say the least, undesirable. The combustion chamber must be so designed as to ensure absolutely complete combustion of gas and it should not be cooled by the cooling water too soon. There should be adequate cooling. Mr. Birks is using gas at a temperature as high as 150°. I am in two minds about the desirability or otherwise of that; it does not seem to be wise to put that hot gas into holders, but possibly that is more a matter for engineers than the chemist. The inlet air or gas going to the machine must be free from any possibility of contamination by coal gas. That remark might sound to be far-fetched; but if the purging machine is near another holder which is not being purged, and if a holder is being purged during stormy weather and a high wind is blowing, it is conceivable that a gasholder-lute might blow and some of the leaking gas find its way into the purging machine, and if that happens it will blow up the machine. It is, therefore, wise to keep the machine well away from the holder that is being purged. All the gadgets connected with the machine, whether on gas engines or motor drives, should be absolutely flameproof I am not sure whether the Harrison machine complies with that requirement entirely as regards a gas engine; perhaps Mr. Birks will deal with that matter. There should be no possibility of backing-up from the holder into the machine. If gas and air inadvertently were going forward alternately, and if there were backing out, an explosion might easily be transmitted from the machine. I am not sure that the seal mentioned in the Paper disposes of that difficulty; I should not like to use it as a non-return valve for an explosive mixture.

It is desirable to provide a machine of reasonably large capacity, so that the time occupied by the purging operation is as short as possible. One of the drawbacks to this method at present is that it does extend the time occupied by the operation three or four fold, as compared with the method applied previously. Mr. Birks' machine has an output of 35,000 cu.ft. of inert gas per hour, and we are using one in Birmingham having an output of 40,000 cu.ft. per hour. Whereas previously we could get through the operation of purging in the period of a shift, the operation now occupies a day or two, and it is a matter of endurance; some of our young enthusiasts have worked right round the clock, without resting at all.

The portability of the machine is also very important, and it seems to me that we want a machine designed somewhat on the lines of a fire engine from the point of view of portability; in a fire engine we have an immense amount of energy and capacity, and it is certainly mobile. I believe that if we could get away from weights of standard pipes, etc., and used some of the alloys available to-day we could reduce the weight by half.

The control of the quality of the purge gas is fairly simple either by straight analysis or by means of the mono-recorder, which we have found to be extremely useful. The matter of the safe end-points for the mixture in the holder is not quite so clear. Mr Birks is using the CO_2. I am not altogether sure that the figure for the amount of combustibles left, as calculated from the CO_2 content of the mixture, is very reliable. The washing water used in the purging machine dissolves a certain amount of the CO_2 out of the inert gas, so that that factor varies to some extent and possibly may influence the assessment of the amount of combustible gas left in the holder. I think that matter needs a little further thought. Mr. Williams is calculating on the CO content. I was rather interested as to whether it was possible, in purging operations of this description, to secure a separation of the gases in the holder by internal diffusion. If there were a layer of steam, we might get the hydrogen concentrated in the stream, and so on.

The end-point when drip oils are present gives considerable concern. The Americans have overcome the difficulty largely by the hot wire catalytic indicator. We have done quite a lot of work on that, and I have come to the conclusion that it is rather a complicated instrument to use, and that unless it is used with very considerable care and knowledge it may mislead. It needs to be considered further. But if we can satisfy ourselves that it is quite reliable, it does overcome the difficulty of the end-points from combustibles due to drip oil and the evolution of the dissolved combustible gases from the holder water. I should like to see the Safety Rules Committee, with the help of a few co-opted gas explosion experts, draw up a code for the Industry on the lines of the very admirable code which the American Gas Association has drawn up. I would recommend a careful reading of that American gas code, for it contains a tremendous lot of information which will help us in the safe use of purging plants.

The PRESIDENT: I think the excellent discussion will indicate to Mr. Birks how much this very important Paper has been appreciated.

Mr. BIRKS intimated his intention to reply to the discussion in writing.

Retort House and Exhauster Governing on Gas-Works

By G. DOUGILL, M.Sc.,
Gas Light and Coke Company

Communication No. 173

A simple and reliable retort house governor has been designed which gives extremely good results under very onerous conditions, and it is felt that the facts which led to this design are of general interest to gas engineers, and may assist them in the elucidation of obscure troubles which they may have experienced.

THE " B.K." GOVERNOR

REQUIREMENTS

There are difficulties in using relay governors. The forces available from the diaphragm are necessarily minute, and the difficulties of utilizing these forces without friction or lost motion are serious, particularly when the difficult conditions of a retort house are remembered. Another difficulty lies in the fact that the repair and maintenance of relay governors often requires a highly skilled fitter.

There are, however, on the market, designs embodying the relay principle which are both robust and yet free from friction and other drawbacks, but these types are not cheap, and even they do not always work well after maintenance unless handled skilfully. Of course, under some conditions relay operated governors are essential, particularly where steam throttle or large butterfly valves have to be controlled from a distance. These conditions, however, do not apply to retort house governing. In the first place it is not difficult to place the governor very close to its work, and as the pressure drop across the valve is usually only of the order of 1 or 2 in. w.g. a very light frictionless valve can be used.

Under these conditions it was thought that it should be possible to design a governor suitable for retort house work without having recourse to the relay principle. The following conditions must, however, be fulfilled:

(1) Friction of valve and operating gear must be practically zero.

(2) Inertia of the moving parts must be low to allow rapid acceleration from rest to check sudden deviations of pressure, and to allow this rapid movement to be checked suddenly without overshooting the mark through high momentum.

(3) Design must be accessible and of a type familiar to Gas Works operatives and easily maintainable by them.

(4) Buoyancy error must be small, *i.e.*, the governor should maintain the same value of pressure over a wide range of movement of the valve.

Early charts had demonstrated that an ordinary bell type of governor could perform good work under arduous conditions and a thorough investigation was made into the possibility of improving this type of governor. To give some idea of the magnitude of the forces concerned, calculation shows that the force exerted by 1/100 in. w.g. on a bell 2 ft. 6 in. in diameter is 4 oz. On existing governors this force had to accelerate a mass weighing about 5 cwt. and consisting of a heavy shaft, reel valve and bell counterbalanced by C.I. balance weights. This heavy weight required a stout beam and heavy knife edges.

As regards friction, there were the anti-friction wheels below water line which guided the bell, the reel valve rubbing in the casing and that of the knife edges. It was therefore decided to reduce the inertia and friction as follows:

(*a*) The valve should be made to close upwards instead of downwards and the bell should be suspended at the end of the beam opposite to the valve. This would balance the one against the other and reduce enormously the C.I. balance weights required.

(*b*) The valve rod should be only $\frac{1}{4}$ in. in diameter and the valve of thin sheet construction. The bell could be made of aluminium or thin monel metal and reduced in depth. Each reduction in weight would reduce the stresses on the beam and enable still lighter construction to be used without sacrificing strength.

Various Designs

These proposals were put before a firm of governor manufacturers, who submitted several designs embodying them. The one approved as being most satisfactory was as shown in Figure 1. This embodied a stainless steel sheet metal

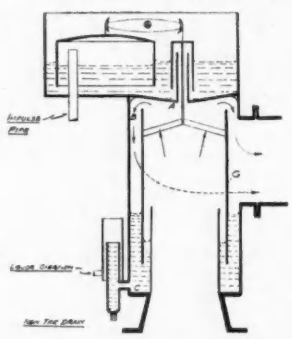


FIGURE 1.—*Diagrammatic Sketch of First Governor.*

beam on edge with the bell and valve at each end as desired. The valve consisted of a thin tube of bakelite sealed at the lower end in water. The gas inlet was at the bottom and the outlet at the side. After various modifications had been incorporated an 18 in. governor was constructed and put to work. The improvement over the ordinary type of governor was so encouraging that three others were fitted in another retort house in which the exhauster conditions were rather difficult.

The working of these was very disappointing. Repeated trouble occurred through thick tar settling in the bottom of the valve seal and preventing the valve from working freely. It was then realized that the throttling of the gas and its efflux from the valve ring in close contact with the outer walls was acting as a tar extractor. Moreover, the outlet being at the side was pulling the valve tube towards it and causing considerable friction on the centre rod.

An entirely new design was evolved, embodying an outer gas collecting chamber of nearly volute type in which tar deposition would be encouraged away from the moving parts, and the walls of the inner seal were raised so that the valve tube was not subjected to any side pull. In addition to this, a restricting ring was inserted at the bottom of the volute to ensure more even distribution of the gas round the valve tube, which would also assist in avoiding side pull on the valve; the outlet connexion was lowered so that the gas was drawn downwards, thus again reducing any tendency to side pull in the valve; and a rearrangement of the bell chamber was made. In the original type the bell chamber was not circular and any sudden movement of the bell tended to make a liquid surge in the chamber. In the new design, Figure 2, the bell

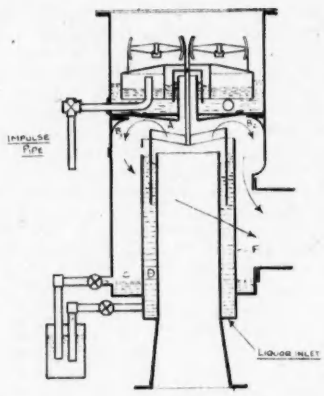


FIGURE 2.—*Diagrammatic Sketch of Proposed New Design of Governor with Downward Flow.*

chamber was made circular and an annular bell surrounded the valve rod which was sealed as usual by a cap. Two very short light beams supported the bell at three places near its periphery at one end and the valve rod at the inner end. An advantage of this arrangement was that the 3-point suspension of the bell needed no sliding contacts to guide it vertically, thus avoiding a cause of friction which had given trouble previously. The whole design made a very compact arrangement, with a parallel walled outer casing.

An alternative design, Figure 3, in which the gas flowed

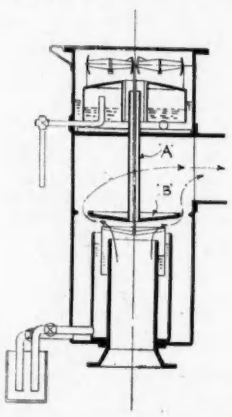


FIGURE 3.—*Proposed Arrangement for New Governor with Annular Bell and Upward Flow.*

upwards from the valve to a chamber between the valve seat and the bell chamber, was also possible, and where a high side outlet was required this type might be preferable. This design is therefore shown separately. Tar deposition is encouraged in the outer chamber where interference with the free action of the valve is unlikely. Apart from the fact that the gas flow from the valve was upwards, this design was identical in principle with the alternative scheme already described.

Experimental Modifications

Although it was felt that one of these designs would overcome the difficulties, it was thought desirable to modify the existing three governors, both to improve their performance and to test out as far as possible the new points of the design, and much experimental work was carried out on them.

Tar Deposition

Finally, a very simple miniature tar tower was designed to deal with the tar deposited in the governor. A piece of 6 in. main was bolted on the side of the governor as shown

in Figure 4. It was separated from the bottom of the governor seal by a parallel slide valve. Another parallel slide valve was fitted to the bottom of the 6 in. main which was 18 in. below the bottom of the governor seal. This miniature tar tower allowed the thick tar and lumps to drain continuously from the governor and settle in the

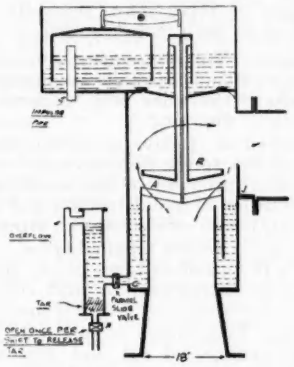


FIGURE 4.—*Proposed Temporary Modification to Existing Governors.*

bottom of the tower. The liquor rose upwards and flowed away at a fixed height to the return liquor tank. Once per shift when the governor was examined by the foreman the thick tar and any lumps were run off downwards through the drain valve.

In addition to this a small steam pipe was inserted radially in the base of the liquor seal. The end of this pipe was welded solid and a small hole was drilled in the side so that the issuing steam circulated the liquor rapidly. Steaming in this way was found to soften any tarry lumps and enable the seal to be drained thoroughly. This was found to be a cheap and rapid method of cleaning out the governors, although at a later date it was only required at infrequent intervals. On opening the governor after 12 months' work, during which time steaming had been carried out on an average once per month, no sign of pitch or solid matter was to be found. It may therefore be concluded that steaming had no detrimental influence.

Removal of Side Thrust

These alterations made a great improvement to the performance of the governors but did not, of course, remove the side thrust. Measurements of the governors showed, however, that it was possible to do this and convert them to practically the alternative design of upward flow governors. Figure 4 shows how this was done.

Upward Flow Design

The vertical 2 in. tube (marked A in Figure 3) which acted as the inner wall of the seal to the bell chamber was lengthened downwards and the bottom was used to support a fixed valve disc B. The valve tube was shortened to work on this new valve disc, and the gas off-take at the side was partially blanked across its lower quarter to ensure that the whole of the gas flowed upwards before turning to the right. As can be seen this incorporated the main principle of the new design though it still lacked the outer chamber for tar deposition and the improved bell design.

One governor was converted to the above design and worked so satisfactorily that the other two soon followed. These governors have now run for several years with very satisfactory results and are maintaining similar standards continuously.

Downward Flow Design

The success of these three governors encouraged a further order for three governors of the complete new design. The downward flow pattern was chosen as being more compact and as having a slightly superior system of volute. In this case owing to existing foul main connections it was not easy to erect the governors on the top of the retort bench close to their work and they were erected accordingly on the working stage level and fitted with long impulse pipes 1½ in. in diameter. Fortunately the foul mains from the top of the bed were of ample size and an alternative impulse pipe to the foul main at retort level was also fitted.

Further governors of this design have since been ordered and erected with equally satisfactory results.

GENERAL CONSIDERATIONS IN CHOICE AND INSTALLATION OF GOVERNORS

All governors commercially available have some advantages and would therefore be of most use under some particular set of circumstances. The difficulty lies not only in assessing the qualities of the governor but also the circumstances. The following notes may be of interest as recording opinions based upon the facts available to the Author.

Interaction

A most difficult lay-out for governor work is one where two battery or retort house governors of equal size are connected to a common main which leads to one exhauster governor. The difficulty lies in the ease with which "interaction" of the governors starts and is maintained. The action appears as follows. If one retort house governor opens for some reason, it reduces the suction in the common outlet main. This causes the other to open during the time that the exhauster is accelerating and tends to increase the acceleration to an amount greater than is necessary, thus causing the suction to be increased above normal. If then the retort house governor which opened first also closes first, the second retort house governor again follows, and starts a symmetrical sequence of "interaction." The fact that the two retort house governors are of equal size and type is apt to aggravate this trouble. A lay-out which usually gives less trouble consists of three or more retort house governors to a common main, which is controlled by one exhauster governor. The movement of one retort house governor has then only one-third (or less) effect.

The remedy for this interaction is the provision of some form of time lag, preferably in the exhauster governor. If this be a water-sealed bell, the provision of an inner gallery with a controlled orifice is very useful, as fitted on many governors (Figure 5). This allows free action for small deviations, but for larger ones the movement of the bell either lifts or depresses the water level appreciably in the inner annulus, thus momentarily increasing or decreasing the loading on the bell. Flow of water through the adjustable orifice allows this alteration of the loading from normal to return to its correct value at a desired rate. Actually when a deviation from the governed pressure occurs this design allows the bell to move so that some predetermined proportion of the correction is applied

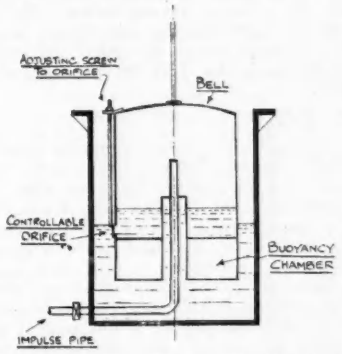


FIGURE 5.—*Bell Governor—Anti-Hunting Device.*

immediately, and the balance more slowly at a controlled speed. This gear is highly desirable for exhauster control, as it is useless to open the steam valve of an engine faster than the steam can be utilized. Similar devices are available for relay governors.

The action of these types of gear is preferable to the control of the air above the bell by a needle valve. Not only is a minute air flow more difficult to control than a liquid flow, but this type of control tends to confine the valve movement more nearly to one speed.

The Impulse Pipe

Construction

The next point to be considered in choosing or laying out a governor system is the impulse pipe required. It is most important where coal gas is being governed to ensure that this pipe (and the recording gauge service) are filled with gas, particularly in the case when pressures below atmospheric are being used. A gauge on the charging stage of a horizontal retort bench, with a service to the top of the bench, will indicate 1/10 in. w.g. incorrectly, due to indrawn air when the service has been momentarily disconnected for cleaning or other purposes. Some time is taken for the gas to diffuse in and displace the air, particularly if the gauge be of bell type and has become full of air. The same conditions apply to the governor bell. Until the bells and services of both the

gauge and governor are full of gas, both will work incorrectly if the service pipe is of any appreciable height.

A very satisfactory way of curing this trouble is to pass a small feed of clean gas from the lighting mains through a water-sealed bubbling bottle into the gauge service and impulse pipe near the instruments. This has many advantages in that it rapidly displaces air and foul gas, and not only avoids the trouble stated above, but reduces corrosion in the governor and gauge bells and reduces the chance of blocked impulse pipes. Another small point is that it is advisable to erect from the foul main a vertical 2 in. or 3 in. pipe 3 ft. in height and take the impulse pipe from the top of it. This vertical pipe acts as an air-cooled reflux condenser and thus reduces any chance of condensation taking place in the gauge service or impulse pipe.

Dimensions

If gas were incompressible and only a small diaphragm were used, the length of the impulse pipe within quite wide limits would have little effect on the working of a governor. Movement of the bell, however, implies a definite flow of gas, which can only occur when there is a difference of pressure between the two ends of the impulse pipe. For good governing the difference in pressure between the two ends of the pipe should rarely exceed 1/100 in. w.g. Obviously, therefore, a short impulse pipe is necessary where quick action of a governor is required and with intermittent retorts or coke ovens quick action is vital for dealing with the sudden rushes of gas at charging and where anti-dips are lifted.

Installation

Retort House Governors

Generally speaking, it is desirable to arrange for quick-acting delicate governors in the retort house and to put them as close to their work as possible, with a short impulse pipe of ample area. The ideal position is, of course, on the top of the bench and approximately central. It is better to erect the governor on a junction than on a tee, as the violent eddies caused by right-angle bends are not desirable at the immediate entrance to the governor. The impulse pipe should join the foul main away from any possible eddies, as these can seriously interfere with the pressure transmission. If, however, the governor cannot be put on the top of the bed, it may be placed on the working stage, provided the foul main to it is of such ample capacity that the pressure drop through it is negligible.

Exhauster Governors

On the other hand, exactly the opposite conditions apply at the exhauster house. In the first place, owing to the condensers and tar extractors between the retort house and the exhausters, the impulse pipe from the governor needs to be of considerable length, as it must be carried at least to the condenser inlet and preferably to the outlet of the retort house. Secondly, it is useless to fit a governor of extremely quick action for steam throttle valve control, as the engine cannot accelerate or decelerate beyond a certain rate. Thirdly, it is not wise to put two sensitive governors in series, as interaction is likely to occur. It is far better, therefore, to have a slower but more stable action for the exhauster control and a light, delicate, rapid action for the final control at the retort house.

For the exhausters the ideal combination therefore appears to be either (*a*) a large water bell (with submerged water control) operating a frictionless steam valve directly if low-pressure steam is used, or through an oil servo valve if high-pressure superheated steam is used, or (*b*) a relay governor, fitted with a ready means of control of the speed of movement of the valve and, if possible, some form of time lag. One great advantage of the relay gear is the fact that an impulse pipe of only small diameter is required owing to the small volume of gas required to operate the relay.

Selection of Governors

As previously stated, all governors available commercially have some particularly advantageous feature, but rarely is it possible to obtain a compromise including all features, so the design needs to be scrutinized carefully. The following remarks may assist in this connexion:

Direct Acting Bell Type Retort House Governors

The necessary qualities are:

(1) Lightness of moving parts for speed of action and absence of momentum and inertia.
(2) Absence of friction; when empty, a very small weight should move them.
(3) Provision for deposition of tar fog, precipitated by the throttling action of the gas, away from the valve and moving parts.
(4) Ease of cleaning and maintenance.
(5) Dustproofness.

Relay Type Retort House Governors

The four types of relay most generally used may be classed according to their power sources:

(1) Air Pressure. This is frequently used, as it is often available. If not carefully manipulated, irregular movements of the valve may be caused by the compressibility of the air.
(2) Water Pressure. Relays using this source of power are not subject to the disadvantage of (1), but careful corrosion proofing of the working parts is desirable in order to avoid friction and sticking. The water supply also needs careful attention.
(3) Oil Pressure. Relays employing oil power are not subject to the disadvantages of (1) and (2), but are usually more expensive on first cost, though this may be compensated by reduced maintenance.
(4) Electricity. This source of power is also free from the disadvantages of (1) and (2), but introduces complications due to possible failure of supply and difficulties in maintaining clean contacts.

There should be no friction of the mechanism between the diaphragm and relay. Some types have many joints, pivots, links, etc., and lost motion and friction are serious disadvantages.

CONCLUSION

There is little doubt that the use of anti-dips and the so-called " dry " receiving mains emphasizes the need for good governing, since the foul main now has a direct connexion with the retort. In former days, when a liquor seal was interposed, accurate control was hardly so important because, owing to unequal settlement, etc., the seals varied from end to end of the hydraulic main and so prevented the advantage of accurate governing from being observed.

However, the query has often been raised whether accurate governing really pays. Objections are based on the fact that an accurate governor is usually more expensive in first cost and maintenance. It is also pointed out that, as horizontal retorts are in three to five tiers, the lower retorts require different pulls from the upper retorts, and of course a similar effect is operative in coke ovens and vertical retorts.

Although it is impossible to obtain incontrovertible figures to show that improved governing has paid an exact sum, it can be shown that excellent governing may be obtained, by careful choice and design, at very little increased first cost or maintenance. Under these conditions, the objection that full advantage of good governing cannot be utilized because of the design of retorts falls to the ground, as the maximum improvement possible is always better than none. Another very solid advantage is that a further variable or unknown factor is removed from the retort house, a factor which all gas engineers will appreciate, when the therm yield is down. Any saving in therms must, of course, be some proportion of those formerly lost and will vary according to the age and condition of the plant. The most important aspect of good governing, however, is the favourable effect on the retort or oven walls. A steadily maintained pressure of the right value enables cracks and pores to seal by the deposition of carbon, minimizing the wear and tear at these weak places, and it is felt that the maintenance of the settings in sound condition is one of the most valuable results of good governing.

Discussion.

Mr. R. W. Hunter (Gas Light and Coke): The need for the Paper arose from the fact that at Beckton, where we have many large carbonizing units, we have in the course of years introduced various types of governor, operated by bellows and of the relay type, and situated in various positions from the outlet of the hydraulic main to the exhausters. They have been operated in some cases by distant control, by water or by mechanical means, and constant efforts have been made for many years to secure really satisfactory governing of retorts. Unfortunately, as Mr. Dougill has rather hinted in his conclusions, they were associated in some cases with inadequate gas connexions, old connexions which, for the sake of avoiding expense, had been allowed to remain; although as long as forty years ago an attempt was made to introduce mains

graduated in size to overcome pressure drops throughout the retort house. Still in many cases, although improvements had been made, perfection had not been reached. The matter was brought to a head by very serious trouble with relay governors on two batteries each of 30 coke ovens, having a total output of about 16 million cu.ft. per day and pumped by one high-speed exhauster. The governor valves in that case were the 36 in. butterfly, relay operated. The working of the governors in conjunction with the governing of the exhauster was very unsatisfactory. The task was a severe one, because owing to the operation of the ovens, the charging operations and our use of forced draught in order to avoid smoke emission, very heavy increases of volume had to be taken out by the governors.

Mr. Dougill has a peculiar gift. He is a chemist, able to tackle abstruse chemical investigations; and he is also a very skilled mechanical engineer, and, therefore, he forms a valuable liaison between the chemical and engineering staff. He was entrusted with the work of " vetting " the various types of governors and of finding a cure for our trouble. In that he was very successful, and he evolved a device which was afterwards the subject of a patent, and which cured the trouble on the relay governors of the coke ovens. Then he tackled governors of other types in the retort houses. The results of his work and of the operation of the special governor that was evolved in consequence are recorded in the Paper.

Governing Perfection Theoretically Impossible.

Mr. B. R. PARKINSON (British Gas Light): Mr. Dougill has confined his treatise to a straightforward account of difficulties overcome in the daily working of large carbonizing plant, but within these limits I doubt whether anyone in the Industry has probed quite so deeply into the subject of pressure control, in order to establish correct premises from which theory and practice can be evolved. I am glad Mr. Dougill has made clear that perfection in governing is theoretically impossible; for the simple reason that deviation from perfection is the only possible operative force leading to restoration. The task is to reduce this deviation to a minimum, just as we can reduce the inertia of working parts in a governor to a minimum and also reduce friction, but we cannot entirely eliminate them. Mr. Dougill has given us a preliminary study of the " impulse " pipe which plays so important a part in communicating pressure to a governor bell or diaphragm. Nevertheless, I understand that he is not satisfied, but intends, as occasion affords, to extend his investigation.

" Hunting " is an inexhaustible topic, as much a " will-o'-the-wisp " to the governor expert as naphthalene used to be to the chemist. It is of interest to note that making the working parts of a governor comparatively featherweight does not seem to have increased the tendency to " hunt." Possibly the reverse has been effected.

In the design of the B.K. governor, the provision of a liquor-sealed valve was an innovation, the result of which could only be proved by experience. The sleeve-valve was first made of bakelite, but although that material is inert to corrosive influence, it tended to disintegrate. Monel metal was then used, but in one instance after several years even this has pitted at the gas and liquor level. " Staybrite " steel may possibly prove more durable. Aluminium certainly would not stand.

Bearing in mind that every retort house governor is by virtue of its location a potential tar extractor, Mr. Dougill and Mr. Rogers have persevered in the design of the B.K. governor with the idea of side-tracking any deposition of tar and maintaining the valve seal in liquor. In any case a run-off is provided from the seal chamber for occasional clearance. It has been left to Mr. Garlick, of Glastonbury, to introduce a further improvement by connecting this to a small tar tower well below the governor level, and that is a much simpler contrivance than it sounds, consisting merely of a piece of gas main on end communicating with the governor by only one pipe for flow and return.

A retort house governor can be placed at the charging level and its impulse pipe taken up to whatever point of the collecting main is selected for control, and that is very convenient for access to the governor away from the heat and smoke of the settings. But Mr. Dougill tells us that the ideal position is on top of the retort bench; therefore, it may be of interest to note that any enclosed retort house governor can be pressure-loaded from a distance. In reference to relay governors, Mr. Dougill has mentioned four types in general use. May I add one more which, if not common, is at least convenient, as the relay source of power is always ready to hand; that is clean gas, either compressed or at holder pressure.

Mr. J. E. DAVIS: I was introduced to the possible vagaries of retort house governors also in connexion with an experimental setting; and as the object of the experiments was to evaluate, as far as we were able, the importance of accurate governing on the gas yield and quality, the troubles that we experienced with retort house governing had to be solved; and they had to be solved without the help of Mr. Dougill's very ingenious " crime detector." The governing at first was bad, but the governor was a good one. I think it can be said that in most respects it obeyed the rules which Mr. Dougill has laid down. The inertia was low, most of the counterbalance being by a buoyancy chamber. The valve was of the very ingenious basket type, with stepped slotted ports, which gave both sensitivity for small pressure variations and quite a wide range of opening with increase of gas volume. The dashpot effect was introduced by an annulus containing air and communicating with the atmosphere through a petcock. Unfortunately, the governor had been badly abused. Weights were placed both upon the bell itself and, in order to compensate these, on the auxiliary counterpoise chains, thus more than doubling the inertia of the governor. The petcock was closed so that the dashpot effect was exaggerated to the extent of almost putting the governor out of action.

The Paper points out in a very simple manner three or four rules whereby not only may better governors be designed, but good governors may be made to remain good.

Improved Working.

Mr. R. N. WEBB (Leeds): All will agree with the first paragraph in Part II of the Paper (Introduction). There is no doubt that by definitely controlling pressure conditions within the retort mouthpieces, greatly improved retort bench working and carbonizing results are obtained; so much so that they have to be experienced before they can be really appreciated. The practice of careful and more exact controlling or working is increasing. The necessity for it is greater than ever, and the advent of a new type of governor is worthy of full investigation. There are several types of governors, and it may be that no one of them will suit all carbonizing conditions and lay-outs of plant, so that much care is requried in selection. A careful study of the Paper indicates the great amount of thought and experimental work that must have been devoted to the problem before attaining the results recorded in Charts 15 to 19.

One of the great advantages of this new governor, in my opinion, is the extreme lightness of the moving parts. That, and a complete absence of friction, are very necessary owing to the small forces available. Mr. Dougill's governor testing instrument is a very ingenious device. We have never had any device of that description in our own controller, and I can only say that it must be very interesting indeed to watch it at work. In the part of the Paper dealing with the application of the testing instrument it is pointed out that even under good conditions exhausters cannot speed up or slow down quickly enough to meet rapid increases of gas make (as when charging retorts). Perhaps Mr. Dougill will amplify that a little. At the New Wortley Gas-Works we have for some years practised the controlling of retort pressures to within two or three hundredths of an inch water gauge. Our controller is designed to work on acceleration and deceleration. It was described in my Address to the Manchester District Association in July, so that I need not go into details; but the principle is that through the impulse pipe which is carried out from the foul main in the retort house into the exhauster house it is working under a sustained pull, which moves a lever operated directly on to the throttle valve of the engine. So quickly does the pressure condition from the retort house work that scarcely any movement can be seen at all before the exhauster begins to accelerate. At the moment we are making a certain quantity of gas, and from the beginning to the end of the draw the exhausters are asked to speed up only 10 r.p.m. That speeding up is spread over a period of from 50 to 55 minutes, and the exhausters act quite well, inasmuch as our variations are not more than two or three hundredths of an inch. So those who may be thinking of working on those lines have really no need to be very worried about Mr. Dougill's statement, because I think that when he makes that statement he means that the acceleration and deceleration does not act quickly enough to prevent the very slightest mark on his very delicate governor, which, after all, is not, in my opinion, of very great moment when the whole of the conditions vary by only one or two hundredths of an inch water gauge pressure.

One of the reasons why our controller and exhauster work so well and so quickly is that we have large capacity mains; that is absolutely essential. When the retort is charged, both doors can be closed at the same time in our conditions, and owing to the large capacity of the

mains, both cross-sectional and volumetric, the pressure is not shown on our delicate recording instrument.

Having a belief in large foul mains, we felt it was necessary to ensure that the impulse pipe, which was to be about 200 yds. long, was really large enough, and we installed a 3-ft. diameter impulse pipe. We have examined it on several occasions and, perhaps owing to its arrangement in the retort house, where we slope it very considerably and run a concealed dip pipe from it, we have never found any tar deposit throughout the length of that impulse pipe from the foul main to the exhauster.

In the conclusion to the Paper Mr. Dougill states that, although it is impossible to obtain incontrovertible figures to show that improved governing has paid an exact sum, it can be shown that excellent governing may be obtained, by careful choice and design, at very little increased first cost or maintenance, and so on. I agree with all that he says there. One of the principal advantages of careful governing is that the life of the retorts is very considerably increased. I suppose that I should give figures to prove that. At present we are working retorts which have been making gas for 3,600 days, and we are still getting from them gas of a calorific value of about 610 B.Th.U. per cu.ft. That will help to prove the necessity for this very careful governing.

Little Attention Required.

Mr. C. M. Rogers (Beckton): I have had nine of these governors under my eye since the first "B.K." governors were introduced in 1934. They have been running without intermission since. We had a certain number of teething troubles with them, but now they require merely the care of the normal retort house staff. It is true that we have a largish staff at Beckton; it does not follow that, because we have more people able to give attention to these instruments than have other works, the instruments need special care; the fact is that they do not need it. On one occasion we left one of them for 36 hours without running off any tar; admittedly after that time we could see that it was not behaving quite as we should like it to behave, but we then ran off the tar and it resumed its normal good work.

With regard to the later types, more especially the last three installed, they have been working since January of this year and have not given any trouble at all, no maintenance costs having been incurred. The foreman runs off the tar from each governor once per shift, and that is all that we have ever had to do with them. We have fitted to the new type (the annular bell type) steaming services, but we have not found that to be necessary. Partly due, I think, to the large mains in the two retort houses, the gas does not seem to deposit the rather sticky tar that we found in the first one.

In connection with the first set of three, that retort house has always made rather strong ammoniacal liquor, and we have found that if the strength of the ammonia in the liquor goes up to about 14 oz. we begin to get rather sticky tar, due to the chloride content; the dilution of the liquor generally cures the trouble. In the other two houses we do not get a 14-oz. liquor, but a liquor of not more than about 10 oz., and we have not experienced such troubles. I should like to emphasize, as one who has used the machines, that they do work without a lot of attention.

Mr. Dougill intimated that he would reply in writing.

Ignition of Gas by Cold Catalyst

By L. W. ANDREW, B.A., B.Sc., A. B. DENSHAM, M.A., and E. W. VOICE,

Watson House, Gas Light and Coke Company

Communication No. 174

It has been known for a long time that a mixture of air and gas can be ignited in the cold by means of a suitable catalyst. Early in 1932 it was felt that an explanation must be found of the unsuccessful application of the cold catalyst in the past, in spite of the apparent simplicity of this particular method of ignition. The catalyst itself was examined and also the method of application. As a result of this work it is considered that there is now available a catalyst which is such an advance on earlier ones, and the method of application is so much more sound, that the cold catalytic ignition of town gas has a promising future.

It is not suggested that the work, or information, is complete; work is still proceeding in both the Watson House and Fulham laboratories of the Gas Light and Coke Company, in the laboratories of Johnson Matthey and Company, and elsewhere, but it seems profitable at this stage to make any results generally available.

Before the conditions for the action of catalysts were clearly understood it was impossible to compare the performance of different samples, and when detailed investigations were begun at Watson House in 1932 it was uncertain whether what was required was improved catalysts, improved methods of application, or both.

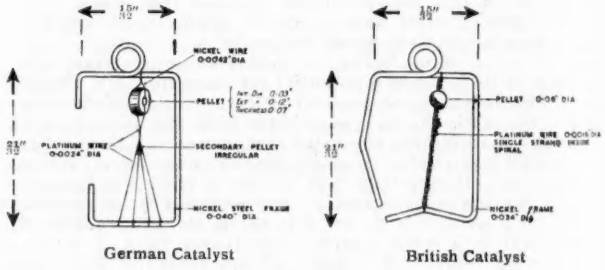
A method of testing catalysts was developed in which the time taken to ignite a 15 per cent. gas-air mixture in a glass tube was measured. Catalysts from a number of Continental sources were investigated, and it was found that those obtained from Germany through Associated Appliances Limited were the most satisfactory. Tests on actual appliances showed that these would work satisfactorily on fires for at least a year; meanwhile Johnson Matthey and Company, who had carried out work on the subject in the past, were asked if they would develop a catalyst at least as good as the German pattern. From this source catalytic pellets have been obtained which in many ways are better than the German—they take less time to light under favourable conditions and require a smaller quantity of gas-air mixture—but unfortunately they are at present more susceptible to poisoning, particularly by oxides of sulphur.

The Design of a Satisfactory Cold Catalyst

The most active catalyst for igniting a mixture of town gas and air is platinum, either in a finely divided state or as a fine wire. Alloys of platinum with other members of the same chemical family must also be considered.

Unfortunately a platinum wire must be heated to 300° C. before catalysis starts. Above this temperature the catalyst causes rapid oxidation of the gas, the heat generated raises the temperature of the wire to 1,000° C. and the gas is inflamed. Finely divided platinum, however, is so much more active that it starts oxidation at room temperature and the heat generated can be used to preheat the platinum wire. This preheating of the catalyst wire is familiar in the electro-catalytic lighter in which a battery is used to heat the wire to the desired temperature.

Figure 1 shows the modern form of catalyst in which a "pellet" of finely divided platinum mixed with refractory


NICKEL WIRE 0·0048" DIA
PELLET
PLATINUM WIRE 0·0024" DIA
SECONDARY PELLET IRREGULAR
NICKEL STEEL FRAME 0·040" DIA
PELLET 0·06" DIA
PLATINUM WIRE 0·0015 DIA SINGLE STRAND INSIDE SPIRAL
NICKEL FRAME 0·024" DIA

German Catalyst British Catalyst

FIGURE 1.—*Catalysts.*

material is attached to fine platinum wires in a suitable frame. When this catalyst is inserted in a gas-air mixture the pellet rapidly heats up and glows, but owing to a blanket of products of combustion does not ignite the gas; the wires in contact with the pellet are heated by conduction to the temperature at which catalysis starts and flash to white heat, igniting the gas.

In order to obtain sufficient information about the catalyst it is necessary to consider separately the behaviour of the pellet and the wires.

The Pellet

It is the oxidation of hydrogen which is responsible for the heating of the pellet; carbon monoxide, methane and other hydrocarbons act as very feeble poisons, but oxidize

and help to maintain the temperature once the pellet is glowing. In order to prevent the accumulation of products of combustion, it is essential to stream gas-air mixture past the pellet; even so there is normally a film 2 mm. in thickness contaminated with products of combustion surrounding the pellet and preventing ignition.

Surface oxidation on the pellet will proceed over a much wider range of gas-air mixtures than can be ignited. The highest temperature is obtained with about 14 per cent. gas, not with the stoichiometric mixture (18 per cent.). The difference is probably due to the greater effect of products with richer mixtures and the preferential adsorption of hydrogen.

The pellet heats itself up to about 900° C. Ordinary platinum black (*i.e.*, finely divided platinum) would rapidly become inactive at this temperature. When heated, the tiny platinum particles sinter together, changing in colour from black to grey; and, since the activity of platinum depends on the extent of its surface (*cf.* active charcoal), the sintering results in a decrease of activity. But, if the platinum black is intimately mixed with refractory material, so that the particles are separated from each other, sintering is largely prevented, and the catalysts remain active. A catalyst tested at Watson House worked satisfactorily 120,000 times, implying that the pellet was heated momentarily to 900° C. 120,000 times. Continuous heating even at lower temperature is much more harmful than intermittent heating, *e.g.*, 1,000 hr. at 300° C., or 10 hr. glowing at 900° C., considerably reduces the activity. It is important, therefore, that a catalyst shall be so fitted to an appliance as not to be heated above 250° C., except at the moment of ignition.

The actual size and shape of the pellet are important. As the pellet gets smaller it reaches a higher average temperature due to reduction in thickness of the film of combustion products and more rapid access of fresh gas to the surface. If the pellet is small enough, particularly if made as a fine thread, it can reach 1,000° C. and ignite the gas without the use of a wire. It would be possible to develop such a catalyst, but there are obvious practical difficulties in mechanical strength, thermal insulation, etc.

As the pellet is normally used to heat a wire it must be of sufficient size to have an adequate heating capacity. The size of the pellets used in practice is a satisfactory compromise and they produce heat at a rate of about 17 B.Th.U. per hr. This heat production is adequate to heat the wires.

The shape of the pellet is worth consideration but has not been very thoroughly investigated. A ring-shaped pellet has a greater surface volume ratio; but a spherical pellet, with the wire passing through the centre, gives better thermal contact with the wire, and is naturally easier to make and stronger mechanically.

As with the pellet, it is hydrogen which is primarily oxidized on the wire, other combustible gases acting as mild poisons until the wire has become hot enough to begin oxidizing them also. Owing to its smaller diameter the wire does not itself produce an appreciable film of combustion products and care is taken in applying the catalyst that the products from the pellet are kept away from the wires.

The effect of the composition of the gas-air mixture is complex; rapid oxidation of gas begins at a lower temperature the weaker the gas-air mixture; but, on the other hand, flame cannot be propagated below about 8 per cent. of gas; and the flame velocity increases with the gas concentration up to nearly the stoichiometric mixture (18 per cent.). Hence a compromise is required, and it so works out that 14 per cent. of gas, the optimum concentration for the pellet, is not far from the optimum concentration for ignition by the wire.

The final catalyst is to be operated in practice in a stream of gas-air mixture in a tube of the minimum size to take it, about ½ in. in diameter. There is a range of mixture strengths and at each mixture strength a minimum gas rate at which the catalyst will operate satisfactorily. Higher gas rates are required for richer mixtures and calculation readily shows that the minimum mixture rate required does not vary appreciably with mixture strength, giving mixture rates of 0·8 cu.ft. per hr. for the Continental catalyst and 0·35 cu.ft. per hr. for the British catalyst.

The application of catalytic lighters would be relatively simple if it were only a question of lighting hydrogen in a dry pure atmosphere. Their limitations in the past have chiefly been determined by the poisoning of catalysts by moisture, sulphur oxides in products of combustion and town air, and various minor constituents of gas. This poisoning is being investigated, and it is anticipated that the knowledge gained will lead to more resistant catalysts.

Poisoning by moisture occurs slowly when the catalyst is left in a damp atmosphere and is independent of the conditions prevailing at the time of ignition, *i.e.*, the catalyst gradually takes longer and longer to work, until it becomes quite inert. The principal action is on the pellet.

Although the avoidance of hygroscopic material greatly decreases the absorption of moisture it will not, however, prevent it entirely. The pellet is necessarily porous, and moisture condenses and is retained more easily in fine pores, so that after standing in a nearly saturated atmosphere the best type of pellet will take longer to work, steam being evolved while the pellet heats up. It may be possible to remedy this by incorporating a drying agent in the catalyst or housing.

The effect of sulphur oxides, which again affect principally the pellet, is to reinforce the poisoning by water vapour. If exposed to the sulphur oxides in products of combustion of ordinary town gas, particularly when cooling, catalysts soon become inactive. It is possible that components of the pellet other than platinum act as inhibitors or accelerators for the oxidation of sulphur dioxide; this point is being investigated.

Neither water nor sulphur dioxide have much action on the wire; even 100 p.p.m. of sulphur dioxide have no appreciable effect on the temperature to which the wire must be heated to start surface oxidation. This is because the wire is not porous and is not sufficiently active to oxidize sulphur dioxide at room temperature.

The minor constituents of gas act as instantaneous rather than slow poisons, since the catalyst is not normally exposed to gas except at the time of ignition. Carbon disulphide is the most important of these; it affects the wire rather than the pellet, so that it is possible, with a high sulphur gas, for the pellet to glow but the wire to remain dull.

The other sulphur compounds in gas—thiophen, mercaptans and sulphides—are present in much lower concentrations than carbon disulphide, which is about 70 per cent. of the total. Ethyl mercaptan, the only one of these tested, has much the same poisoning power as carbon disulphide.

Conclusions

The catalyst should consist of a pellet not more than 2 mm. in diameter supported on platinum wire 0·002 in. in diameter in a frame. The pellet of very finely divided platinum intimately mixed with finely divided refractory material should be porous, but must possess sufficient cohesion to hold together; it must be free from hygroscopic material or from substances easily converted to hygroscopic sulphates, and from materials which promote the oxidation of sulphur dioxide. The wire, which need not consist of more than one strand except for the sake of mechanical strength, should be embedded in the pellet, the latter being about one-quarter of the length of the wire from one end. The frame is conveniently of the shapes and size shown in Figure 1.

For activity the catalyst should be placed in a stream of gas-air mixture containing between 10 and 20 per cent. gas. The mixture should come from below, with the longest piece of wire projecting downward into the stream. A streaming rate of at least 0·35 cu.ft. per hr. of mixture (0·05 cu.ft. per hr. of gas) is required to supply the catalyst with sufficient gas for ignition. Better results will be obtained with gases containing a reasonable amount of hydrogen and minimum concentrations of sulphur compounds or unsaturated hydrocarbons of high molecular weight. For instance, the catalysts will not work on natural gas or producer gas.

The catalyst must be protected against products of combustion of gas, and should not be heated above 250° C., except at the moment of ignition. As far as possible it should be protected from damp, traces of acid in the air, vapours such as ammonia or petrol, and from mechanical shock liable to cause damage.

The present catalysts are of sensible design and the best are satisfactory in use. Unfortunately different consignments show considerable variations in resistance to poisoning; but it is anticipated that the reasons for these variations will soon be cleared up.

CATALYST HOUSINGS

Flued Gas Fires

The gas fire is an easy appliance to convert to cold catalytic ignition. The burner is reasonably accessible, there is not much dirt around the fire and a short delay before ignition is tolerable.

Figure 2 shows a housing relying only on flame lift to clear products of combustion from the catalyst. A neat housing of refractory material is fitted with a groove to take the catalyst. It is inserted into a hole cut in the firebrick back at a convenient point. A tube taken from the burner is fitted with a special pilot head giving one main jet pointing towards the housing and another main jet pointing towards the radiants of the fire. Sub-

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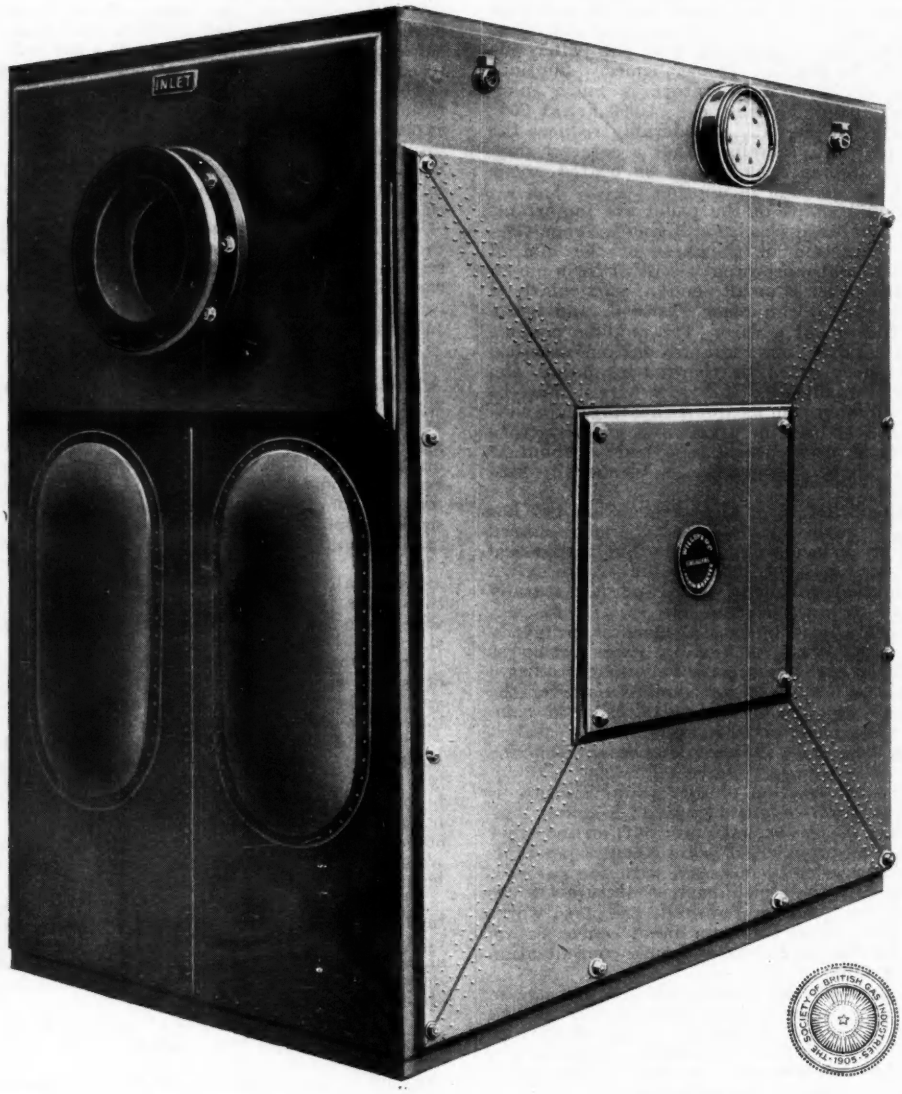

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sidiary jets ensure that the main jets ignite from one another. On turning on the fire, one jet is ignited by explosion from the housing, and this lights the other main

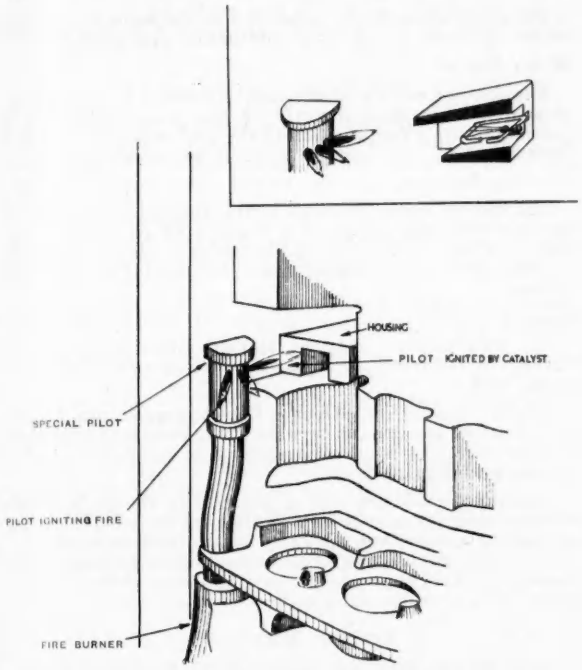


FIGURE 2.—*Housing for Flued Gas Fires, utilizing Flame Lift.*

jet which ignites the fire. These jets are alight for the same period as the fire.

This method gave fairly satisfactory results on district test, the catalyst having a life of over 12 months, and in certain cases over 2½ years. The life of the catalyst is normally about 500 hr. because of incomplete clearing of the products of combustion if the location of the housing is not exactly correct. It is not easy to fit to all fires, however, and the location is not definite.

The results of this simple housing were so satisfactory on the district that all available information was circularized to the gas fire industry in 1935. Since then development work has also been carried out in the laboratories of the Parkinson Stove Company, Limited, and this firm has put practical housings on the market.

Figure 3 shows a housing using a bimetallic strip, and two others taking advantage of flue pull to remove the products. In the figure:

5. This housing, developed by the Parkinson Stove Company, gave rapid ignition from cold.

   An injector fitted to the gas fire burner fed the gas-air mixture to the housing. As soon as the mixture ignited, an explosion flame from the chamber holding the catalyst passed over the burner teat immediately behind the housing and the fire ignited. A bimetallic strip, heated by the flame on the injector, rapidly intercepted the flow of products and isolated the catalyst. Ignition could not take place again until the bimetallic strip had cooled down—about 8 min. after turning off the fire.

6. This was a later development by the Parkinson Stove Company, parallel with work carried out at Watson House, to eliminate the moving parts from housing 5. The method of fixing to the fire and of applying the ignition is similar to that of housing 5, but a new principle is introduced to prevent products of combustion from reaching the catalyst. A flue pull and an offset catalyst produced the desired effect.

   The housing gave satisfactory performance cold and hot. On the gas fire for which it was designed the concentration of gas passing over the catalyst was 13·8 per cent., and the gas rate 0·11 cu.ft. per hr., but when hot this rate fell to 0·07 cu.ft. per hr. As expected, ignition when cold occurred in about 3 to 6 sec., but ignition of the fire when hot was unreliable. The housing did not behave well on fires other than the one for which it was designed.

7. This was developed at Watson House in parallel with housing 6. It gives satisfactory performance cold and hot. It utilizes an offset catalyst and a balanced type of flue. This balanced flue effect reduces the effect of heating up, although the products of combustion are completely cleared. On one fire the gas rate over the catalyst when cold was 0·13 cu.ft. per hr. and 0·10 cu.ft. per hr. when hot. It operates over a number of different fires and has a wider range than 6, probably because the gas flow over the catalyst is helped by convected heat from the pellet. The delay in ignition is about 5 to 8 sec. The extra delay is probably due to the greater volume of the housing.

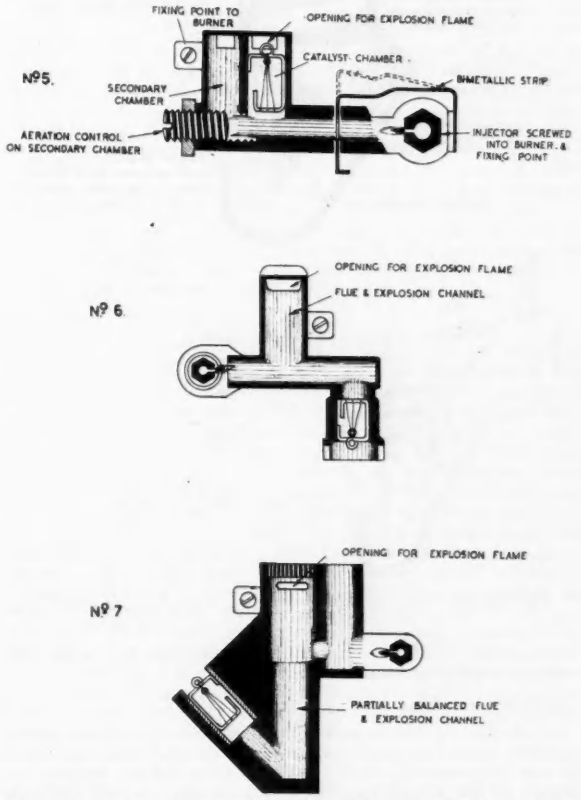


FIGURE 3.—*Housing 5 with Bimetallic Strip; Housings 6 and 7 utilizing Flue Pull.*

Housings 6 and 7 have been proved by district experience, but a later type has been designed and appears to be an improvement.

8. Figure 4 shows this improved type. It is designed to keep the gas rate at a higher value over a wide range of temperatures and to obtain this gas rate at a low injector pressure. Previous housings have tended to work only on fires with a high aeration and large burner pressure, and this has limited the chance of producing a universal housing. The new housing on a typical fire gives a gas rate of 0·18 cu.ft. per hr. cold and 0·16 cu.ft. per hr. hot, and a mixture strength of 15 per cent. gas.

   A special double pilot jet is taken from the gas fire burner so that one flame points almost downwards into a balanced flue containing the catalyst in the far limb. The other jet points slightly upwards so that it fills a tortuous passage with gas-air mixture. This passage leads to the burner teats. On turning on the fire the lower pilot jet is ignited by explosion from the catalyst, the flame being transferred to the upper pilot which ignites the mixture in the tortuous passage. An explosion flame from the end of the passage ignites the fire.

   The main catalyst housing and the upper chamber are quite distinct parts, and the clearing of the products depends on flame lift. The upper chamber exerts a negligible pull, and this ensures that some gas-air mixture stagnates in it even when the housing is hot. The design of the upper chamber is independent of the rest of the housing, and this gives scope in applying the ignition to any type of fire. A flash tube from this chamber can transmit a flame any distance up to 5 or 6 in.

The precise method of manufacture of such a housing has not been considered in detail, but one form has been

applied to four different types of hearth and panel fires, and it seems likely that two designs would be satisfactory on any of the fires now available. If such a housing were applied to new fires it would be possible to cast the greater part of it integral with the burner and to use a pressed

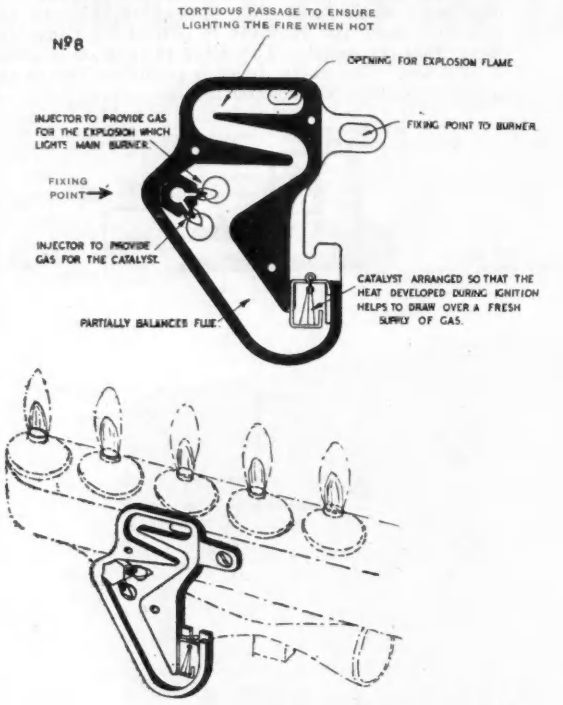

TORTUOUS PASSAGE TO ENSURE LIGHTING THE FIRE WHEN HOT
No 8
OPENING FOR EXPLOSION FLAME
INJECTOR TO PROVIDE GAS FOR THE EXPLOSION WHICH LIGHTS MAIN BURNER
FIXING POINT TO BURNER
FIXING POINT
INJECTOR TO PROVIDE GAS FOR THE CATALYST
CATALYST ARRANGED SO THAT THE HEAT DEVELOPED DURING IGNITION HELPS TO DRAW OVER A FRESH SUPPLY OF GAS.
PARTIALLY BALANCED FLUE

FIGURE 4.—*An Improvement on Housings 6 and 7.*

metal cover to form one outside wall and to locate the catalyst and pilot positively.

Flueless Gas Fires.

A device is incorporated which the consumer must operate before ignition takes place so that the appliance is not left until ignited. This extra device makes the design of the housing particularly simple, as the products of combustion may be allowed to pass over the catalyst until they are cut off completely by manual operation.

9. This can be accomplished in a number of ways, *e.g.*, using an obturator between the jet and the catalyst, moving the catalyst away from the injector, or cutting off the gas at the injector. This last method was adopted by the Parkinson Stove Company, and details are given in Figure 5, housing 9. The gas only flows to the pilot as long as a knob is lifted.

Practical experience on the Gas Light and Coke Company's area last year was satisfactory, ignition taking place in from 2 to 6 sec.

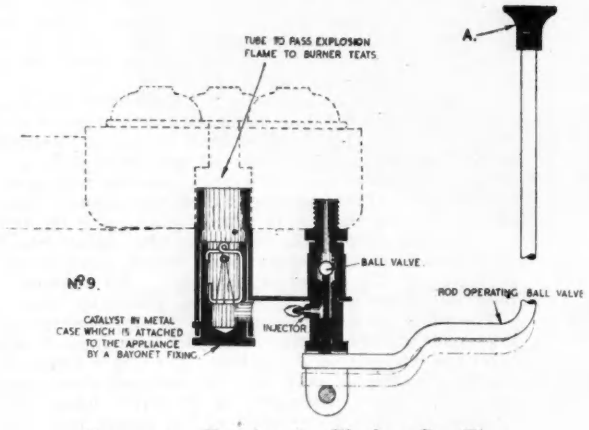

TUBE TO PASS EXPLOSION FLAME TO BURNER TEATS
A.
No 9.
BALL VALVE
ROD OPERATING BALL VALVE
CATALYST IN METAL CASE WHICH IS ATTACHED TO THE APPLIANCE BY A BAYONET FIXING.
INJECTOR

FIGURE 5.—*Housing for Flueless Gas Fires.*

The catalyst is mounted under the burner, and is arranged in a chamber connected at the top to the main burner, and at the bottom pointing towards an injector. A supply of gas-air mixture is fed to the injector from the burner chamber, and controlled by the ball valve which is opened or closed by the rod attached to the knob A. To light the fire the knob A is raised and when released, after ignition, cuts off the supply of gas to the catalyst.

Refrigerators

The application of cold catalyst does not seem worth while as the appliance should be in continuous operation.

Water Heaters

The delayed action of the catalyst would lead to an explosion if it operated directly on the main burner. It is possible to use a combination of the cold catalyst, pilot and thermo cut-off, and such a development is anticipated.

Lighting Burners

The limited space available in the domestic fitting has so far prevented the design of a housing which would be reliable hot and cold. It should be easier to obtain a suitable housing for outdoor lamps, and experimental housings are in hand.

Cookers

The cold catalyst may be applied either direct to the burners or indirectly to a pilot on flexible tubing attached to the cooker.

Direct Application.—Oven.—Direct application to the burner would be unsound because of the danger of explosion. A pilot and thermo cut-off device would probably be satisfactory and is being tried.

Indirect Application.—It is possible to design a simple catalyst to ignite a pilot on a flexible tubing hanging at the side of the cooker, but the delay before ignition must be at a minimum because the cook is standing by waiting for the ignition. (This type can be used to ignite either the hot-plate burners or the oven as desired.)

District Experience

District experience and nearly all the laboratory experience is limited to the gas supplied on the Gas Light and Coke Company's area. About 2,000 gas fires using housing 6 and 2,000 flueless gas fires using housing 9 have now been on the Gas Light and Coke Company's area for one heating season. Before this large scale test about 180 experimental housings of various types were tried out over periods up to 2 years under district conditions. Detailed information on the 4,000 fires is not yet available, but it is definite that a housing designed on the principles discussed is satisfactory; and the experimental housings which proved unreliable in practice have some understandable weakness in design.

The behaviour of the catalytic pellet itself is also as anticipated. There have been some failures on the British type of catalyst when this has been used very intermittently during damp weather. The recovery of the pellet after the appliance is once ignited is satisfactory. At the moment it has been decided to change the pellet once each year during the normal maintenance period. Experience indicates that the catalyst could be left for a greater period, say, 2 years at least, but further practical confirmation of this point is required.

As a result of these practical tests, and of prolonged laboratory tests, some idea of the time lag before ignition and the life of the present catalyst can be given.

Delay in Ignition

A slight delay is inevitable even with a housing of ideal design, but the period of delay will depend very much on local conditions. If a catalyst is in constant use the delay will be negligible, but if it is only used after long interims in damp weather there will be a longer delay and under certain conditions failure may occur. If a catalyst does fail it will recover normally if heated and this generally takes place if the appliance is ignited in the normal manner.

Table 1 summarizes laboratory and district information.

TABLE 1. - *Delay in Ignition—After Turning on Gas—Using a Well-Designed Housing.*

Condition.	Delay in Seconds.	
	Catalyst 1 (Continental).	Catalyst 2 (British).
1	2	3
Frequent use—normal surroundings ..	2 to 3	1 to 2
„ „ —cold and damp surroundings	2 to 3	1 to 2
Daily use—normal surroundings	3 to 4	2 to 3
„ „ —cold and damp surroundings ..	5 to 7	5 to 7
Occasional use—normal surroundings ..	5 to 7	5 to 7
„ „ —cold and damp surroundings	7 to 12	May fail

The catalyst can be reactivated easily if it does fail due to damp conditions.

As far as the life of the catalyst is concerned an en-

durance test of 100,000 ignitions over 6 months did not show failure and this is a typical result for tests of this type. A life of greater than 2 years under practical conditions can be predicted and it is probable that, given an ideal design of housing, the period could be extended for many years.

GENERAL CONCLUSIONS

Cold catalytic ignition using a commercial catalyst in housings designed according to simple principles has given reasonably satisfactory results in the area of the Gas Light and Coke Company. Experience has not, however, been obtained on many gases outside this area of supply.

These results and improvement in the catalyst and in the housing suggest that this type of ignition is sufficiently far advanced to be accepted commercially as an effective method.

A summary is given below of the inherent merits and weaknesses of cold catalytic ignition:

Merits

1. Simplicity of principle and design—few parts, simple to understand.
2. Cheapness.
3. Ease of application to different types of apparatus.
4. Ease of maintenance and low maintenance cost.
5. Only part which may need exchange is standard.
6. Novelty.
7. Easy application of distant control.

Weaknesses

1. Variable delay in ignition.
2. Some temporary failures due to local conditions.
3. Catalyst is fragile to handle.
4. Dependence on gas composition.
5. Dependence on atmospheric conditions.

Work on this subject is still incomplete, especially as far as the effect of gas composition is concerned. Existing results are, however, sufficiently encouraging to suggest that future development may make cold catalytic ignition the simple type of universal ignition which is awaited.

Discussion.

Dr. COWARD (Assistant Director, Safety in Mines Research Board): I should like to see a much more intimate analysis of the process of ignition in their apparatus; for one thing it might help me in my own work. In dealing with that intimate analysis they might perhaps tell us how they measure the thickness of a burned-out layer of gas on the surface of the catalyst; and they might also explain, for example, in relation to Figure 2, why the maximum temperature reached by a pellet is attained with 14 per cent. of gas, whether that gas be hydrogen or coal gas, when they also say that it is only the hydrogen which reacts, because in the 14 per cent. coal gas there is about 7 per cent. of hydrogen and in the 14 per cent. hydrogen there is 14 per cent. I do not understand why the maxima coincide. If they would care to deal, in such detail as I think would be helpful to others, with the process of ignition, possibly one of the chemical societies would be a more appropriate body through which to secure publication.

If the Authors continue their work, and if they find a catalyst which will do the same for methane as theirs is doing for hydrogen, I hope they will inform those concerned with safety in mines, because it would be a most valuable contribution to safety to bring forward a catalyst which, starting from cold, sets fire to methane.

Dr. HAROLD HARTLEY: It was established by Bone and Wheeler that in the union of hydrogen and oxygen over a variety of catalysts both metallic and non-metallic, and including platinum, even in mixtures containing an excess of hydrogen the re-action velocity was determined by the partial pressure of the hydrogen. Between 1909-12 when working with Prof. Bone at Leeds on the same phenomena, I found also that with mixtures of CO and O_2 the partial pressure of the combustible gas again determined the velocity of the re-action in a particular experiment. My work conformed with the earlier experience of Bone and Wheeler and I will enumerate some of our particular findings.

In general, starting with a new catalyst, the value of "K," the re-action constant is initially *subnormal*, but in successive experiments rises steadily until after the circulation of the mixture, maybe for several days, it attains a *normal* activity, which is characteristic of the state of the surface under the experimental conditions. The activity of catalysts can then often be enhanced temporarily by circulation of the combustible gas, but is, in general, not stimulated and may even be decreased by the circulation of oxygen. In some cases, such as with copper oxide, the effectiveness of the surface is very much reduced by contact with air.

Prof. Bone and I examined the effect of the presence of water vapour on the activity of surfaces. We found, for example, in the case of fireclay that the "K" value attained with a moist $2CO + O_2$ mixture (18 mms. aq. vapour) was doubled when the system and gases were dried by liquid air. In these experiments the catalyst, its containing tube, and the gas in contact with the surface were heated to 500° C., while under the conditions of use of a cold catalyst in a piece of gas apparatus the temperature of the surface and the combustible mixture is well below 100° C. when the initial formation of water occurs. Platinum black is finely divided and will adsorb water molecules tenaciously, and these, by rendering inactive temporarily a part of the catalyst, limit the rate of self-heating, or even prevent it taking place. I would suggest that therein lies the explanation of Mr. Andrew's experience of the need for increased mixture rates to ensure adequate self-heating with increase in the percentage of coal gas present. This view seems also to be supported by the results summarized in Figure 2.

Affinity of Methane.

In flames and explosions the affinity of methane far exceeds that of hydrogen for oxygen; but in the pre-flame combustion of mixtures of $CH_4 + 2H_2 + O_2$ in contact with a solid the order of things seems to be completely reversed, and the hydrogen is burnt much more rapidly than the methane. Thus, when circulating such a mixture over fireclay at 500° C., I found in 1909 that, after seven hours, less than 5 per cent. of the methane had been oxidized, while over 85 per cent. of the hydrogen had been converted into water. In the previous year Mr. Forshaw's experiments had shown that with the same actual catalytic material $2H_2 + O_2$ combined some 2½ times as quickly as $2CO + O_2$, and that when a mixture $H_2 + CO + O_2$ was circulated, the hydrogen was oxidized more rapidly than the CO. The rate of oxidation of the CO in the three gas mixture in Mr. Forshaw's experiments was, however, much more rapid (in one experiment 33 per cent. in three hours) than that of the methane in mine. It would seem likely, however, that under the conditions of Mr. Andrew's experiments some pre-flame combustion of CO and methane will occur and that CO especially may be helpful in accelerating the attainment of the required ignition in the homogeneous phase.

The catalytic activity of surfaces often increases very rapidly with temperature; and in a careful examination of the change of the re-action constant "K" for a silver surface in the presence of moist $2CO + O_2$ over the temperature range 350° C. to 400° C., I found that not only did "K" increase with "T," but that $d\mathrm{K}/d\mathrm{T}$ also increased rapidly with "T." My work with this catalyst emphasized the very marked effects attributable to the concentration of the re-acting gases within the solid phase. For example, when measuring $d\mathrm{K}/d\mathrm{T}$ it is essential to hold the surface at the experimental temperature for several hours before determining "K" if a spurious result is not to be attained. If the catalysts were held, immediately prior to the determination of "K," at a temperature above that at which the required circulation was to be made, I found the value attained was subnormal. Conversely, if the surface were kept below the experimental temperature for some time before the experiment, the value of "K" was above normal. In general, my experience suggested that after any change of temperature or pressure in the re-acting system an appreciable interval of time must elapse before a catalyst re-attains a steady state. I would also emphasize that while adsorption phenomena are undoubtedly of first importance, the ability of the gases to penetrate within the catalyst materially influences the rate of combustion. Prof. Bone and I arrived at the conclusion that the function of the catalyst was to activate both the oxygen and the combustible gas.

May I ask the Authors if they have interpreted the results in Figure 4 which seem anomalous. Had the activity of the platinum been decreased by the additional work put on to it in the production of the finer gauge? And two other questions—Are the variations in the ignition delays primarily due to variation in the rate of heating of the pellet, or the wire, or both? Have the Authors investigated the possibility of effecting improvement by increasing the catalytic activity of the wires themselves?

The circulating method devised by Prof. Bone over 30 years ago and since used by a considerable number of research workers in his Laboratories lends itself so well to the examination of catalysts and their control, that I

commend its consideration to Mr. Andrew and his colleagues if they decide to continue their work in the direction of developing catalysts.

An Unnecessary Handicap.

Mr. C. A. MASTERMAN (Gas Light and Coke): Some ten years ago when I first joined the Gas Industry it appeared to me a severe and unnecessary handicap to gas appliances that their operation in the absence of a pilot light invariably depended upon the use of matches. This fact was the more surprising in that many cigarette lighters were available with flint ignition and independent flint lighters were frequently used in the kitchen. Catalytic ignition of gas was also familiar over a hundred years prior to this and in primitive form the platinum wire igniter, unreliable though it was, was also familiar in the kitchen. Since that date many gas appliances have been developed containing manually operated igniters and provided these are reliable they are an added convenience to the consumer and must encourage the greater use of the appliances to which they are attached.

For ignition to be truly automatic, however, the gas-air mixture should be caused to inflame as soon as formed without necessitating any other mechanical movement. The catalytic ignition of gas has therefore been under review at Watson House for a number of years and received extra encouragement when sample pellets and wires were obtained showing an activity and reliability far in advance of any hitherto achieved. By so arranging these pellets as to cause the optimum air-gas mixture to reach them and thereafter prevent products of combustion passing over the pellet, reliable ignition was obtained on sample appliances for periods exceeding two years, without attention. Work continued both on the pellets and their arrangement and on housings until 1935, when developments appeared so promising that touch was established with most of the appliance manufacturers in this country and our information put fully at their disposal.

It was not to be expected that with so new and relatively untried a device all manufacturers would at once adopt this arrangement commercially. The Parkinson Stove Company, however, notably carried out work and introduced a device on to a series of fires with which we have now had a considerable amount of experience in consumers' homes, and it is satisfactory to be able to report that the results are a great encouragement, since even in these early stages the reliability of the cold catalyst is found to be, broadly speaking, not inferior to the reliability of alternative devices.

The Paper summarizes a great deal of further work which has been carried out at Watson House and points to yet more reliable forms of housing and potential improvements in the catalyst itself such as to lead to closer approach to 100 per cent. reliability and minimum delay in operation. That any device shall be completely 100 per cent. reliable must exceed human expectation, but that we are within striking distance of self-igniting gas seems to me beyond question. That there are certain dangers in this, though not serious ones, is borne out by an experience we had in one of our showrooms a short while ago. A fitter having removed the fire temporarily was improperly dealing with live gas, a sufficiency of which reached a fire which was fitted with cold catalyst and there inflamed. Fortunately, precautions against such an incident are easily taken and its occurrence only confirms the stage which this development has now reached.

I imagine it would never be sound policy to advocate the unqualified use of cold catalytic ignition on such appliances as water heaters, cooker ovens, &c., where delay in ignition might lead to an explosion, but in combination with a thermo cut-off the catalyst in its full development would appear even in such circumstances the perfect method of obtaining ignition without further action on the consumer's part.

In presenting this Paper at an Institution meeting it is hoped to draw attention to the potentialities of this method of obtaining self-igniting gas and to outline the technical considerations which must be observed. So far as our information goes at Watson House, in the interests of the Gas Industry we shall be very glad to co-operate with any manufacturers of gas appliances who may consider this development of interest to them.

Resistance of Platinum to Poisoning.

Mr. R. H. ATKINSON (Mond Nickel Company): The information summarized in Figure 6 leaves no doubt that platinum is more resistant to poisoning by sulphur compounds than its alloys containing 10 and 20 per cent. rhodium or iridium and therefore likely to be a more satisfactory catalyst. Before, however, the alloys of platinum are dismissed from further consideration it would be interesting to know the behaviour of 1 per cent. rhodioplatinum. I make this suggestion because the Authors state in their introduction that they are continuing with the work. The behaviour of palladium is not altogether surprising because it is known that palladium readily combines with sulphur when heated in contact with it.

Have the Authors any information as to the purity of the platinum used both for the pellets and the wires? Have they found any difference between the behaviour of commercial platinum and physically pure platinum such as is used for thermocouples? It is conceivable that very pure platinum might be a more active catalyst and at the same time less susceptible to poisoning.

In September, 1936, I had one of these cold catalyst fires installed in my house, and my wife has been so satisfied with it that we have bought another one. Although there is a slight delay in ignition, there is never any unpleasant explosion such as may occur when lighting a gas fire with a match. When the first fire was installed the delay in ignition was about 7 seconds. The maximum delay ever observed was 13 seconds after the fire had not been used for several months during the summer; this delay included the time necessary to purge the gas pipe, a factor which is difficult to allow for under service conditions. This particular catalyst is now entering on its second winter and appears to be in as good condition as when installed. So far as I am aware the catalyst has not been changed.

Those who have experience of the use of catalysts in other industries realize the importance of catalyst support, and it would be a good thing if we could have some information concerning the catalyst support used here. Have the Authors information as to the composition of the refractory? Has silica gel been tried? Silica gel is a very satisfactory support for platinum in the contact process for the manufacture of sulphuric acid.

Mr. L. C. MYERSCOUGH (Johnson Matthey & Co., Ltd.): As one of the principal refiners of platinum, my Company has always been interested in its use as a catalyst, but it was not until 1936, when we were approached by the Gas Light and Coke Company, that serious research was started on the ignition of coal gas by platinum catalysts. In the following year we were able to produce in bulk the catalytic lighter, the performance of which is described in the Paper. Our catalyst, although reasonably satisfactory in use, is still imperfect, but intensive work is proceeding, and the development of even more efficient means of ignition is anticipated very soon. Our success has been due in great measure to close co-operation with our friends at Watson House; they have always been pleased to place their services at our disposal, and we should like to take this opportunity of thanking them for their collaboration, criticism and advice.

Mr. R. N. LEFEVRE (Gas Light and Coke): I should like to stress the point raised by Mr. Masterman. From the service viewpoint we should welcome the advent of the catalyst igniter in gas appliances since it represents a further advance in the direction of eliminating human and mechanical factors. The fitter who installs the appliance and the man who subsequently services it have no complicated mechanism to adjust and, perhaps, what is more important, there are no tempting screws to twiddle. It either works or it does not, and in a few isolated instances in which it does not, the filament can be changed in a moment. The same considerations apply from the point of view of the user. There is nothing to get out of adjustment and no reason to interfere with it, and in the unlikely event of ignition not occurring automatically it is necessary only to use a match. Then, when next the fire is used, ignition will be satisfactory, since the use of the fire reactivates the catalyst.

Mr. ANDREW intimated that he would reply in writing.

7th Report of the Liquor Effluents and Ammonia Committee

Communication No. 168

Research Chemist: A. Key, D.Sc., Ph.D.
Research Assistant: W. Etheridge, B.Sc., A.I.C.

Tests on Gas Liquor Concentration Plant at Coventry Gas Works

During the past year it has been possible to carry out a large number of tests on the gas liquor concentration plant at the Coventry Gas Works. The plant is of the Thorncliffe Baldurie type and, because it utilizes the still and building belonging to a disused sulphate of ammonia plant, is probably not quite as efficient as a plant which is entirely designed for concentrated gas liquor production. The plant employs a decarbonator and is intended to produce a liquor containing 20 per cent. ammonia by weight. After preheating, the crude liquor, with sufficient steam to raise its temperature to about 90° C., passes to the decarbonator, which is a vessel situated on top of the still proper. In this vessel vigorous splashing of the liquor results in a certain proportion of the carbon dioxide it contains being volatilized, and this passes away to atmosphere by way of a scrubber, which retains ammonia, and an oxide bed, where hydrogen sulphide is removed. The liquor from the decarbonator is cooled (this is essential) and is then led to the still, where distillation takes place in the usual way, only the free ammonia being removed. The gases from the still are condensed, producing a liquor of the required strength, which passes to storage. Any uncondensed gases pass through a scrubber, for the removal of ammonia, and then through an oxide bed to atmosphere. The control of the plant is automatic, the amount of liquor supplied being regulated so as to keep constant the temperature of the gases leaving the still. Provision is also made for the automatic shutting down of the plant in case of blockages.

Two series of tests are recorded. The tests in the first series were carried out at a time when the condensing and scrubbing arrangements of the plant were rather different from those just described, and these tests comprise an investigation into the conditions governing the production of concentrated liquor rather than performance tests of the plant. It was found important that the liquor entering the still from the decarbonator should be cooled sufficiently; otherwise insufficient steam is allowed to enter the base of the still and the liquor is incompletely stripped of its ammonia. The Coventry plant demands an inlet still temperature not greater than 50°-52° C., but for other plants this will vary with the type and condition of the still and the strength of the decarbonated liquor.

Much trouble has been experienced in concentrated liquor plants with the formation of solid deposits which blocked the condenser and the connexion between this and the condenser scrubber. It has been shown that these blockages are deposited from the gaseous phase directly on the surface of the pipes and that they can be entirely prevented by keeping all surfaces washed with concentrated liquor. At Coventry the plant could be kept free from deposits indefinitely by replacing the later stages of the condenser by a vertical washer packed with rings, down which the condensate was allowed to flow with the uncondensed gases. The rapidity with which deposits built up could be reduced by increasing the degree of decarbonation, by increasing the throughput (to decrease the condensing efficiency), and by bringing the condenser scrubber close up to the condenser.

Partial decarbonation was found to increase the ratio of ammonia to carbon dioxide in the concentrated liquor and thereby render it possible to manufacture a stronger liquor without risk of crystallization, but its effectiveness in this direction was not as great as would be expected. It was also found that the ratio of ammonia to carbon dioxide in the product depended on other factors besides the degree of decarbonation. In general this series of tests showed that the ratio could be increased by intensive cooling of the gases from the still, by avoiding excessive contact between liquor and uncondensed gases and by decreasing the efficiency of condensation.

The tests in the second series were more complete and were all carried out with the plant in its normal form. Sufficient measurements were made to allow of the working out of weight, ammonia and heat balances, which were usually satisfactory. The weight unaccounted for of liquor and steam passing through the plant averaged 0·9 per cent. of that entering; the ammonia loss averaged 2·6 per cent.; and the steam heat unaccounted for, which included that lost by radiation, that required to drive the turbine liquor pump and any wetness of the steam, averaged 11·6 per cent.

In no case was there any difficulty in producing the strength of product required, and any desired strength within fairly wide limits could be produced by adjusting the still head temperature and the condensing efficiency.

The net efficiency of the decarbonator was almost entirely dependent on the temperature of decarbonation, and increased rapidly between 82° and 90° C., being about 30 per cent. at the latter temperature. Some ammonia as well as carbon dioxide was removed from the crude liquor in this part of the plant, but the amount could be minimized by supplying as great a quantity of crude liquor as possible to the top of the reflux sections surmounting the decarbonator. It would seem that the efficiency could, if desired, be further improved, without appreciable extra operating costs, by increasing the number of reflux sections and also the temperature of decarbonation.

In the tests which were carried out the efficiency of condensation of ammonia was most markedly affected by the throughput of the plant, a greater throughput resulting in a lower condenser efficiency. This is apparent in Figure 1, from which it may also be seen that, other things being equal, the greater the amount of decarbonation the smaller the amount of ammonia condensed. The condenser efficiency is important, not only because all the ammonia remaining uncondensed must later be redistilled, but because it indirectly affects the liability of the resulting concentrated liquor to crystallize.

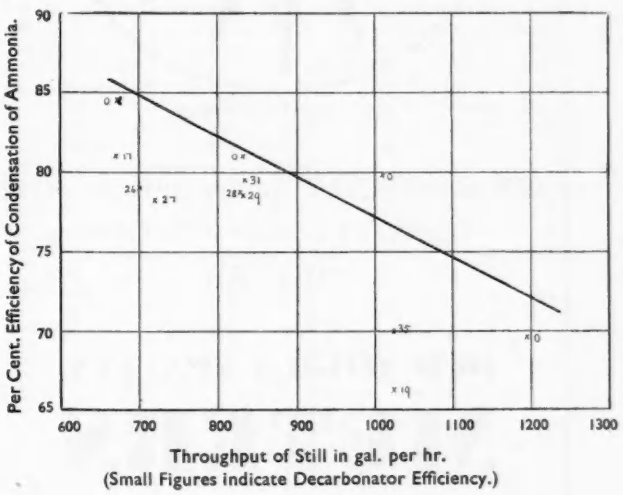


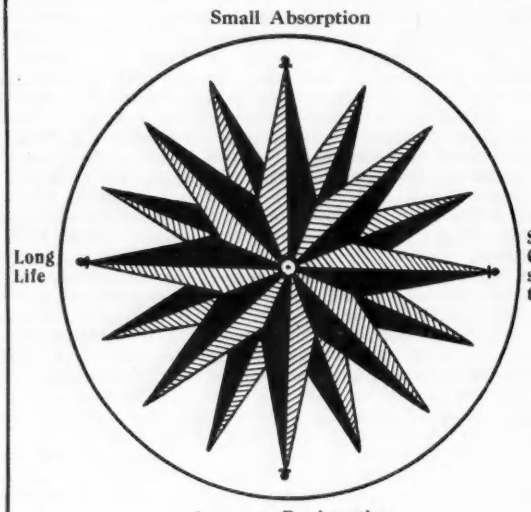
FIGURE 1.—*Coventry Concentrated Liquor Plant Throughput of Still Plotted against Condenser Efficiency.*

The production of concentrated liquor in the condensers appears to proceed as follows. Firstly water condenses, and this is followed by the absorption of ammonia in the condensed water. This process takes place with great rapidity at first, but the velocity of absorption then falls as the ammonia content of the liquor increases and the amount of uncondensed ammonia diminishes. Absorption of carbon dioxide takes place slowly at first, but this process later becomes more rapid as the uncombined ammonia content of the liquor increases.

Thus the lower the efficiency of condensation of ammonia the greater the ratio of ammonia to carbon dioxide in the final product and, as has been pointed out above, the greater this ratio the stronger the liquor which can be prepared without risk of crystallization. Figure 2 shows how this works out in practice. Here the throughput of the still is plotted against the ratio of ammonia to carbon dioxide in the product and the straight line connects the points representing tests where there was no decarbonation. It will be seen that as the throughput increased from 700 to 1,200 gal. per hr. the ammonia-carbon dioxide ratio also increased from 1·05 to 1·22, the maximum possible liquor strength, crystal-free at 10° C., increasing from 18·4 to 20·4 per cent. ammonia by weight.

It is also apparent from Figure 2 that the further effect of decarbonation is to raise the ratio of ammonia to carbon dioxide in the product, rendering possible a stronger crystal-free liquor. In general, 30 per cent. effective de-

All the Cardinal Points



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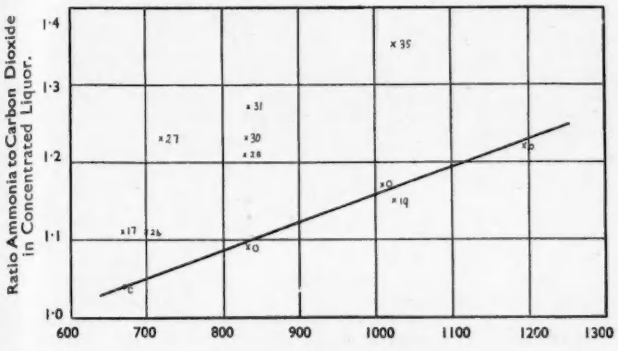


FIGURE 2.—*Coventry Concentrated Liquor Plant Throughput of Still Plotted against Ratio of Ammonia to Carbon Dioxide in Product.*

carbonation increased the ratio by 0·15-0·20, rendering it possible to make a liquor about 2 g. per 100 g. stronger in ammonia without crystallization. The diminution of the carbon dioxide content of the final liquor caused by 30 per cent. decarbonation was only 10 to 15 per cent., again indicating that the effect of decarbonation is not fully reflected in the character of the concentrated liquor. It has been deduced that hydrogen sulphide is removed in the decarbonator to a greater extent than carbon dioxide. Absorption of hydrogen sulphide in the condensers is also more rapid than that of carbon dioxide and it is not noticeably influenced by the efficiency of ammonia condensation.

The most satisfactory method of working the scrubbers which deal with the uncondensed gases from the decarbonator and the condenser is to use the minimum amount of scrubbing liquor which will effectively cool the gases. If more than this is used more carbon dioxide than ammonia is extracted, which tends to annul the work of the decarbonator.

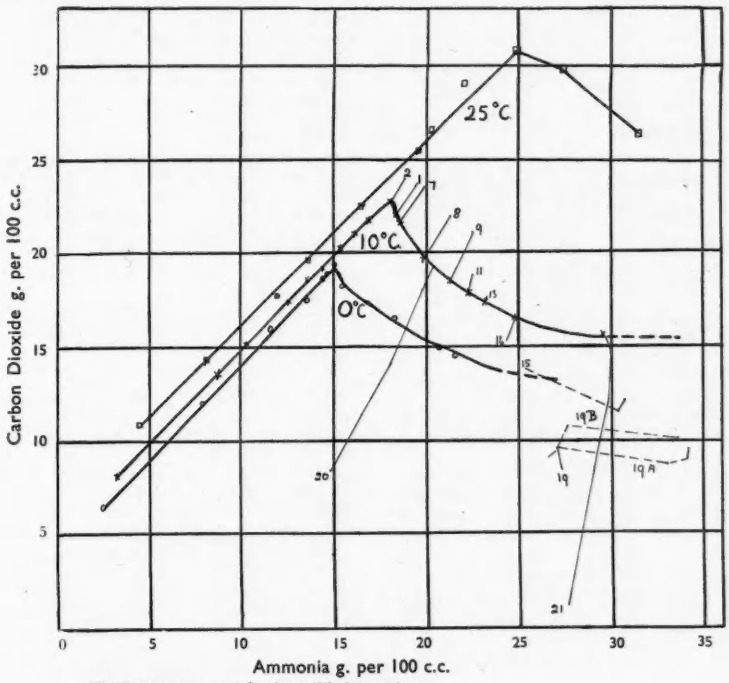
A study of the economics of concentrated liquor manufacture emphasizes the great importance of having as strong a crude liquor as possible, particularly if decarbonation is employed. Where transport charges are high it is also important that the product should be as concentrated as possible without risk of much crystallizing. In this connexion a decarbonator assists, but only in rare cases will it prove an economic proposition on these grounds alone. This, however, is not its only use.

By suitable adjustment in design it should be possible to enable the decarbonator to remove much more carbon dioxide from a liquor without appreciable extra cost. This would enable a much more concentrated crystal-free liquor to be prepared, with consequent reduction in transport costs, but this advantage might be offset by the increased difficulties of handling the liquor and by accidental ammonia losses.

The Crystallization of Concentrated Gas Liquors

In the manufacture of concentrated gas liquor for conveyance to a central chemical works for working up, it is desirable that the product should not deposit crystals to an extent hampering storage or transportation. It is therefore important that the conditions under which this liquor will and will not crystallize should be known. An investigation has been carried out with this object in view.

It has been found that, depending on its composition, concentrated liquor may deposit crystals of ammonium bicarbonate, normal ammonium carbonate, or a double salt composed of two molecules of ammonium bicarbonate and one molecule of normal ammonium carbonate. It has also been shown that, particularly in the case of liquors which deposit crystals of the normal carbonate, there is present in the solution ammonium carbamate, which is produced from, or converted into, normal ammonium carbonate by a reversible reaction. Any crystals of ammonium carbonate which may be deposited will, of course, be in equilibrium with the ammonium carbonate in solution, but, if this is not also in equilibrium with carbamate, they will bear no quantitative relationship to the total ammonia and carbon dioxide present in the liquor. There is thus the possibility of liquors of the same composition crystallizing or not crystallizing, according to relative concentrations of carbonate and carbamate. This possibility might produce rather disturbing results in practice were it not that the equilibrium carbonate-carbamate appears usually to be displaced, if at all, towards the carbamate side. There is thus more likelihood of liquors remaining liquid when they might be expected to crystallize than of the reverse happening.



Thick lines connect final equilibrium values.
Thick dotted lines are extrapolations.
Thin lines refer to 10° C. and connect intermediate compositions.
Thin dotted lines connect determinations between which ammonia gas or ammonium bicarbonate had been added to the solutions.

FIGURE 3.—*Compositions of Concentrated Gas Liquors, from Sulphide, in Equilibrium with Crystals at Temperatures of 0°, 10° and 25° C.*

The reaction carbonate $\rightleftarrows$ carbamate is very slow at air temperatures and takes days or weeks to reach equilibrium. When this is attained with the liquor in contact with crystals the composition of the solution becomes fixed and represents the final composition of a saturated solution. The thick continuous curves in Figure 3 connect

series of such final compositions of liquors free from sulphide. Liquors having compositions which, when plotted, come below these curves will not normally deposit crystals at the temperatures for which the curves are drawn. Liquors of compositions which come above the curves may or may not immediately deposit crystals when cooled to the temperature concerned (depending on the relationship of carbonate to carbamate), but will ultimately crystallize if allowed to remain for a sufficiently long time at that temperature. For any particular ammonia concentration the maximum carbon dioxide permissible, if crystallization is to be avoided with certainty at 0°, 10°, and 25° C., can be read off from the curves.

In that composition range where liquors deposit ammonium bicarbonate or the double salt, the curves show that as the ammonia content of the equilibrium solution rises the carbon dioxide content also increases, but immediately the normal carbonate constitutes the solid phase the curves change direction and increasing ammonia content is accompanied by decreasing carbon dioxide content. The change in direction at 10° C. occurs at 15·8 per cent. ammonia by weight, which is intermediate between the 15 per cent. liquor, which is usually made in plants without a decarbonator, and the 20 per cent. liquor, to produce which plants with a decarbonator are usually employed. The change in direction of the solubility curve provides the reason why liquors of 20 per cent. ammonia by weight cannot usually be prepared without risk of crystallization unless steps are taken to reduce the carbon dioxide content. This is further shown in Figure 4, where the weight

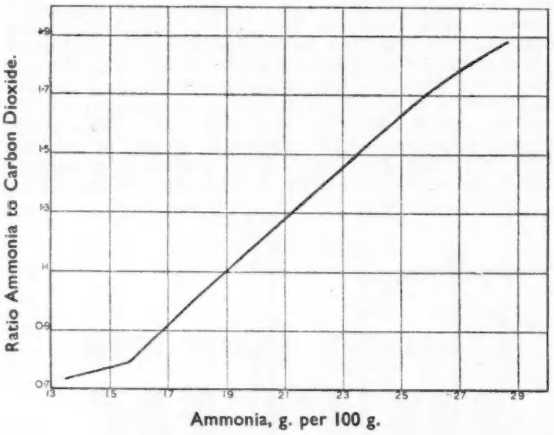


FIGURE 4.—*Concentrated Liquor, free from Sulphide, in Equilibrium with Crystals at 10° C. Ammonia Content plotted against the Ratio of Ammonia to Carbon Dioxide.*

percentage of ammonia in liquors in equilibrium with crystals at 10° C. is plotted against the ratio of ammonia to carbon dioxide in the liquor. It will be seen that after 15·8 per cent. ammonia this ratio must increase rapidly as the ammonia content increases, if crystallization is to be avoided.

The influence of temperature on the solubility of ammonium salts in gas liquor is considerable, and under the same conditions of production a stronger liquor could be prepared in summer than in winter without the possibility of crystallization occurring.

As far as has been determined the presence of sulphide reduces the carbon dioxide content of a liquor in equilibrium with crystals, and as a rough approximation each 1 per cent. of hydrogen sulphide can be taken as replacing 0·5 per cent. of carbon dioxide in equilibrium mixtures.

The Relationship between Density and Composition of Concentrated Gas Liquors

In view of the importance of the amount of carbon dioxide in determining the liability of a liquor to crystallize, a rapid method of estimating this substance would clearly be useful. It has been found that the ammonia content, the carbon dioxide content, the sulphide content, and the density of a liquor are connected with each other by the formula

$$\text{Density} = 1 - 0{\cdot}0040\,NH_3 + 0{\cdot}0094\,CO_2 + 0{\cdot}0050\,H_2S.$$

The concentrations are expressed in g. per 100 c.c. and the density is that at 15° C. compared with that of water at the same temperature. Since the ammonia content and the density of a liquor are determinations which are usually made at a Works, this formula may readily be used to obtain an approximate figure for the carbon dioxide content, from which, by the use of the curves shown in Figure 3, the liability of a liquor to crystallize can be gauged. In the equation the term involving sulphide is usually small and the use of the formula would not normally require more than occasional sulphide determinations.

Discussion.

Mr. A. L. HOLTON (Manchester): Perhaps I may suggest that the last sentence of the conclusions on test series A, in Part III of the report, might be more clearly expressed. It is stated there that in general the NH_3/CO_2 ratio can be increased by intensive cooling, avoiding excessive contact of liquid and gas, and by decreasing the efficiency of condensation. On the face of it, "intensive cooling" and "decreasing the efficiency of condensation" appear to be contradictory. It seems clear that the successful manufacture of concentrated ammoniacal liquor involves a careful balance of many factors, not all of them in the same direction—as, for instance, the amount of steam used in relation to the throughput of the still, the efficiency of decarbonation and its effects, the efficiency of condensation, and the relationship of these and other factors to the economics of the process. I would suggest to those of you who have been puzzled as to why a works mentioned in the report can produce liquor of very much higher concentration than that from your own works, or, *vice versa*, that the answer is to be found in the 7th Report.

May I urge those of you who are marketing concentrated liquor, knowing something in regard to its uses and the pressure that may be brought upon you, to use greater care in the handling of the liquor. In concentrated liquor there have been found certain colouring bodies that are definitely detrimental to ammonia and to the processes in which concentrated liquor is being used. Speaking to a wider audience than is gathered here, for I imagine that all here are very keen workers and are careful of the handling of their liquor, I do want to suggest that by careful separation of tar and liquor and careful handling of it, particularly in using ammoniacal liquor for concentration purposes, care will be well repaid and may enable you to avoid considerable trouble in the disposal of it in the days to come.

In previous years I have been rather a strong critic of the disposal of ammoniacal liquor into the drains without having subjected it to any treatment whatever. Some small works have tried evaporation on the step grate and know something of the mess—to use no stronger term—that it gives there. I want to refer to a small device that I have in operation on a plant that is used mainly for experimental purposes in the undertaking which I serve. It is quite a simple arrangement. A 6-in. square tube is built into the brickwork at the top of the setting, with a liquor inlet to the side and then a side branch leading directly over the damper from the vertical retorts. The tube that is set into the brickwork is continued, and then by a piece of 12-in. main taken from the top of the stack to the bottom I have filled it with Paschig rings and have put openings at the bottom. My first experiment was to put the liquor in at varying rates, pass it through the tube, where it was heated, and then through the tar, air being drawn in by induction from the pull of the chimney. My second experiment was to add a little steam at one point, and the third experiment was to supply hot air at one point. As the result of using the device, in each case, taking varying rates, the reduction of free ammonia has been of the order of from 90 to 95 per cent., and the reduction of sulphuretted hydrogen has been in the region of from 85 to 95 per cent. So that when the liquor has been passed through that device there is no likelihood of trouble arising in the sewers from either H_2S or ammonia. In addition, there is a reduction of the O/A figure of from 30 to 40 per cent. I have only just tried the device, and whether or not I shall be able to get better figures in the future I do not know; but I think it is of sufficient interest to warrant mentioning it to those who are in trouble with regard to the disposal of liquor and may enable them to achieve some measure of success. There is a very definite reduction of the thiosulphates, evidently due to oxidation, and the thiocyanates also show a definite reduction, but the results are not too consistent. The other oxidizable constituents also show a progressive reduction, as measured by the O/A figures. There is strong evidence that in addition to the direct removal of the H_2S and the free ammonia by the current of air there is some oxidation, which assists in the still further reduction of the O/A figure.

Passing on to another matter which is somewhat unusual in this connection, I want to draw attention to experiments that we have been carrying out at Manchester during the past year. The Corporation own quite a number of farms, in connection with the Cleansing Department, and the potato crop has suffered very severely from the eel-worm.

About a year ago we thought it would be advisable to experiment on the treatment of the soil with liquor in order to cure the worm trouble. You are probably aware that at Manchester we have a detarrer and a dephenolating plant. Their operation results in the tar (which is usually just an ordinary tarry deposit on the condensers) being definitely oily and containing a very high percentage of mono-carbolic acid. The liquor itself is quite clear and contains a very high percentage of carbolic acid. A test of our liquor taken at the condensers, with a detarrer in operation before it, gives the following analysis:

Ammonia (free)	0·60	gr. per 100 c.c.
Ammonia (fixed)	0·08	,, ,,
Phenols as C_6H_5OH	0·70	,, ,,
Sulphides as H_2S	0·02	,, ,,
Thiocyanates as CNS	0·04	,, ,,
Thiosulphates as S	0·05	,, ,,

That liquor was used on the soil, during 1937, for the extermination of eel-worm. The land selected had been cropped with potatoes in 1936, and over certain areas of the field negligible yields of potatoes were obtained. One of those areas was used for the experiment. That area was divided into two strips, 40 yd. by 2 yd. One strip was treated with the phenolic ammonia liquor (the analysis of which is given above) at the rate of 2 gallons per sq.yd., applied in two applications at two weeks' interval in April, 1937, the seed being planted in early May—*i.e.*, a fortnight later than the second application, and after cultivation and ploughing. The other strip of land was not treated with the solution and was planted at the same time, after the same cultivation and ploughing. The conditions of test were severe, inasmuch as the normal rotation of crop was not followed. Potato-sick land was used again for potatoes, without any resting period on rotational crop. The remainder of the field on which the experiments were made was cropped with wheat.

The plants on the untreated soil made only slight growth, and finally died. The plants on the treated portion made healthy growth, giving a good root growth and a good yield of potatoes. If I had brought here a sample of the potatoes you might have thought I was a fisherman! But it is an interesting point that in the eating of the potatoes there is no suggestion of the treatment to which the soil was subjected; for instance, there is no carbolic. [Laughter.] You may smile, but I would remind you that that was the trouble with the fish in the Ruhr; it was the very fact that the fish tasted of the effluent that brought this question to light. Our first experiments have indicated the value of the antiseptic treatment of soils, following the classic work of Sir John Russell (J.S.C.I., 1913, p. 1136). Next year we are extending our experiments to other farms; we and the farmers for whom we treated the land this year anticipate similar success. I grant that this is not likely to be of universal application for the disposal of your ammonia, but for potato cropping in some of our country districts it would dispose of quite a large amount in a very useful way.

Need for Cooling the Liquor.

Mr. J. W. Napier: The Research Staff have brought to light certain factors which were not previously fully understood. I am pleased to see that they lay emphasis on the necessity for cooling the liquor after decarbonation. This is most important and failure to observe such procedure has, I believe, in some cases led to other troubles. The fact that a reduction in the efficiency of condensation results in a higher ammonia carbon dioxide ratio, with a consequent ability to produce a better product—*i.e.*, a product less likely to crystallize—is of great importance and is a factor which, I am sure, has not previously been fully understood in the design and operation of such plants. As stated in the Report, this plant was designed to produce a liquor containing 20 per cent. of ammonia by weight, and it was realized that in order to produce this concentration of ammonia it was necessary to reduce by some means the carbon dioxide content of the crude liquor. The amount of carbon dioxide which it was necessary to remove was realized to be relatively small and this has been confirmed by the tests.

It seems to me a pity, therefore, that the expression "efficiency of decarbonation" has been used, repeated, and expressed in two different ways. I mention this merely as a warning, because when examining these efficiency figures and finding that they vary between 10 per cent. and 35 per cent., it is possible to have the impression that the decarbonator is relatively inefficient, whereas in order to achieve the specified duty it is only necessary to remove a portion of the carbon dioxide in the decarbonator, then if that portion of the carbon dioxide is removed the decarbonator is surely working with an efficiency of 100 per cent. In view of the fact that the ammonia carbon dioxide ratio depends not only on the decarbonator but also on the method of condensation, it appears that this statement of efficiency is even more misleading.

One of the assumptions which has been made is that the ratio of ammonia to carbon dioxide in the crude liquor is unity. In view of the fact that the strength of concentrated liquor which can be produced depends so very largely on this ratio, it would be interesting to examine the costs for different ratios and at the same time to express the maximum strength of liquor which can be made with and without decarbonation for these different ratios.

If such figures were set out together with the relative values of liquor of different strengths, then the costs would give a truer indication of the value of decarbonation and would be more applicable in practical cases. This criticism is applicable to all general cost figures.

Mr. P. Parrish submitted a written contribution, which was presented by Mr. Botley.

Absorption Rate of Ammonia Gas.

Mr. R. J. H. Banks (Gas Light and Coke Company): The specific rate of absorption of ammonia gas into ammonia liquor is a rapid process analogous to condensation, and controlled mainly by diffusion, while that of carbon dioxide is controlled mainly by a reaction in the solution to give ammonium carbonate or carbamate. This reaction depends largely on conditions such as the CO_2/NH_3 ratio in the solution and the temperature. It may, therefore, be relatively slow with a low temperature and a high CO_2/NH_3 ratio.

The total rate of absorption is determined both by the specific rate and by the difference in concentration of NH_3 or CO_2 in the gas and in equilibrium with the liquor, while this equilibrium figure will in turn depend very largely on the temperature and concentration of the liquor. These two effects do not appear to be very clearly distinguished in the Report. The decrease of the CO_2/NH_3 ratio in the concentrated liquor which was found with smaller condensation areas and lower temperatures is probably due to the influence of this specific rate of absorption.

Dr. Key has performed a useful service by giving figures for steam consumptions corresponding to various strengths of crude liquor fed to the plant, with and without the use of the decarbonator. The steam consumption measured on the plant from which our own experience is drawn is 38·5 lb. per 100 lb. of crude liquor compared with the Coventry figure of 29 lb. for a similar crude liquor strength. Of this excess of 9·5 lb. of steam per 100 lb. of liquor, 1·5 lb. is used in the decarbonator, our figure for the steam used in decarbonation being 6 lb. per 100 lb. of crude liquor, compared with Dr. Key's figure of 4·5 to 5 lb. This larger quantity of decarbonating steam used, together with the greater capacity of our decarbonator, probably explains the higher efficiency of CO_2 removal experienced in our plant. In place of the flash chamber of the Coventry decarbonator, the plant now being described follows the washing trays with a series of 9 contact trays, down which the liquor flows countercurrent with the decarbonating steam. The liquor then leaves the decarbonator and enters the main still at 90° C. without any intermediate cooling, and although this temperature is much higher than in the case of the Coventry plant, no subsequent difficulty is experienced in the operation of the main still. It would appear from this that the suggestion that a low still head temperature favours stripping of the liquor is not generally applicable. Expressed in the terms of Table 2, our N_2 efficiency of CO_2 removal averages not less than 50 per cent. The ammonia loss from the decarbonator is negligibly small, and no decarbonator scrubber is required.

The explanation of the remainder of our excess of steam consumption over Dr. Key's lies in the fact that we make no special endeavour to obtain complete absorption of ammonia gas in the final concentrated liquor condenser, but re-circulate any unabsorbed gas back to the coal-gas stream at the inlet of the coal-gas exhausters. The need for a condenser-scrubber and for any elaborate control of the process of condensation is thus avoided, and as the system is completely closed, loss of ammonia is impossible. The excess steam used—in any case relatively cheap exhaust steam—is thus a reflection both of the efficient decarbonation and of this re-circulation system, which together enable us to work the plant in a comparatively trouble-free manner, and to produce from a 1·9 per cent. crude liquor a concentrated liquor of 24 per cent. strength, with an effluent liquor strength of 0·02 per cent. free NH_3.

Dr. Key Replies.

Dr. A. Key, replying to the discussion, said: Mr. Holton is quite right in suggesting that the last sentence of the general conclusions on Test Series A (Part III of the Paper) reads rather queerly. It stated that in general the NH_3/CO_2 ratio can be increased by intensive cooling, avoiding excessive contact of liquid and gas, and by decreasing the efficiency of condensation. It is perfectly true, though it may need just a little re-wording. If we had intensive cooling and allowed that intensive cooling to

increase the efficiency of condensation we should not increase the NH_3/CO_2 ratio. On the other hand, if we decreased the efficiency of condensation by increasing the throughput and leaving the type of cooling the same, we should get the desired increase in the ratio of NH_3 to CO_2. I will try to re-word the sentence, however, so that its meaning is clearer.

I was interested to hear about Mr. Holton's apparatus for removing a great portion of the ammonia from the crude liquor. I do not wish to comment on it in detail, but I should like to give a warning to those who contemplate removing just a portion of the ammonia by some such method. It is quite possible that if you remove a portion of the ammonia in that way you will give rise to a greater nuisance, due to the smell of the ammonia, than if you do not remove any at all, because normally ammonia is present as ammonium carbonate, which has a very low vapour pressure of ammonia. If you remove a portion of the ammonia you will probably remove the whole of the carbon dioxide, and you may have a caustic ammonia product. In Mr. Holton's case that does not apply, perhaps, for he secures the removal of 95 per cent. or so; but where 50 or 60 per cent. removal of ammonia is contemplated, that consideration should be borne in mind.

I am very glad to hear of the experiments on potatoes. In our last report we went into the fertilizing action of crude liquor rather thoroughly, although we did not investigate its action on eel-worm. I am not sure that the phenols have been responsible for the whole of the good effects in the experiments mentioned by Mr. Holton. There are two other factors worth mentioning. First, a dosage of 2 gallons per sq.yd. is equivalent to the application of a fertilizer at many times the normal rate (half a ton or so of sulphate per acre); secondly, free ammonia in gas-works liquor will certainly decrease any acidity there may be in the soil, and it may be that those particular soils were too acid to grow crops and that the correction by ammoniacal liquor may itself have resulted in better conditions for growing.

With regard to the remarks of Mr. Napier, it is quite true that the efficiency of decarbonation may be expressed as 100 per cent. if the job is done, and undoubtedly in this particular case the job was done. At the same time, if decarbonation means removal of CO_2, 100 per cent. decarbonation must mean removal of 100 per cent. CO_2. It is just a question, of course, of reading the report and giving the meaning which is needed. At the moment, with partial decarbonation, all that is needed is the removal of a fraction of the CO_2. We have thought it advisable to record the efficiency as a percentage of CO_2 removal. If we had adopted the 100 per cent. term for a 30 per cent. removal, then in the future, when we wanted to remove 60 per cent., we should have to refer to it as 200 per cent. efficiency.

Another point mentioned by Mr. Napier was that of the costs, and I agree that it would have been advisable to have included the data he wanted. But that could not be done because we had only one liquor with which to carry out our tests, and it would be difficult to say what would be the effect where the CO_2 in the crude liquor varied. The effect might be better where the amount of CO_2 is excessive.

The data presented by Mr. Banks was given rather too rapidly to enable me to comment on it at the moment; but as he gave that data I could see that all his points, except one, fitted in with our experiments, although the fitting in might not be obvious at first sight, and I shall have to go into the one which did not fit in later.

28th Report of the Refractory Materials Joint Committee

Communication No. 169

RETIREMENT OF DR. J. W. MELLOR

Joseph William Mellor, D.Sc., F.R.S., retired on 31st March, 1937, from the position of Director of Research to the British Refractories Research Association, which he had held since the formation of the Association in 1920.

Born in 1869, Dr. Mellor early showed an interest in the ceramic industry although, as his numerous books testify, he has always maintained a close contact with and interest in pure chemistry.

Dr. Mellor's association with the Gas Industry dates from about 1908, at which time data on the properties of fireclay and refractory materials generally were very scanty. His work on the texture of refractories and the refractoriness and refractoriness-under-load tests have been of great importance to the refractories industry and he was a pioneer in measuring the specific heat of fireclay and silica bricks.

On the coming into being in 1934 of the Laboratories of the Association at Stoke-on-Trent these were named "The Mellor Laboratories" in recognition of Dr. Mellor's services to the ceramic industries.

Following his retirement Dr. Mellor has been appointed the first Honorary President of the British Refractories Research Association.

Mr. A. T. Green, F.I.C., previously Assistant Director of Research to the Association, has been appointed to succeed Dr. Mellor as Director of Research.

SUMMARY

The Effect of Hydrocarbon Gases on Refractory Materials.—This subject, of obvious interest to the Carbonizing Industries, has been under investigation since 1935 and the observations described in the 26th and 27th Reports. It has been established that methane may cause the disintegration of certain firebricks at 800° and 900° C., and also that town gas from which the carbon dioxide has been removed is effective at 900° C. The breakdown is caused by the growth of carbon deposits around "iron spots" as nuclei. Experiments described in the present Report disclose the fact that dry town gas, freed from carbon dioxide, causes the disruption of those firebricks susceptible to disintegration much more rapidly than dry town gas containing 3·5 per cent. of carbon dioxide. In these, as in previous experiments, the silica specimens were not broken down. With the dry, CO_2-free gas the tendency to disintegration decreases with the temperature of exposure, and disruption was not, in fact, observed at 700° C. or lower temperatures.

Experiments with ethylene at 600° and 800° C. indicate that this hydrocarbon does not cause the mechanical breakdown of firebricks. Polymerization to benzene and more complex hydrocarbons occurred. It is concluded that methane is the constituent of coal gas which is primarily responsible for the disruption of firebricks at 800° to 900° C.

Jointing Cements.—In the Report for 1936 a description was given of an apparatus which had been devised for investigating the mechanical stability of cement joints in tension or under compression up to temperatures of about 1,400° C. Results were reported for various lime and clay bonded silica cements. The work has now been extended to include silica cements containing ganister and crushed silica brick in admixture bonded either with lime or with a mixture of lime and clay. The data suggest that lime-silica cements containing crushed silica brick in the coarser fraction may be improved in bonding power at high temperature by the addition of a little clay or bentonite. On the other hand lime-ganister cements were not improved in this respect by small additions of ball clay. Several of the silica cements on being maintained at 1,300° C. for three hours under a light load provided joints which possessed relatively high tensile strength at this temperature. In contrast, these same mixtures provided extremely weak joints when heated up to 1,300° C. under very slight tension.

Results are also reported for mixed calcined and uncalcined kyanite-clay cements. There would appear to be some slight advantage in using uncalcined kyanite in the fine fraction as a means of counterbalancing the firing contraction due to the clay.

The Action of Alkali Vapours on Refractory Materials.—Various aspects of this subject have been under investigation since 1933. In the Report for last year it was observed that an expansion of the order of 10 per cent. by volume is induced in fireclay materials exposed to the action of potassium chloride vapour at 1,000° C. The first Paper on this subject is concerned mainly with this expansion phenomenon, but an explanation of the cause is not attempted at this stage. It is interesting to note that coarse-grained sillimanite specimens have been disrupted under the influence of sodium or potassium chloride vapour at 1,000° C. There is also some evidence in the case of

one fireclay product that its strength is decreased by exposure to potassium chloride vapour.

In a second Paper the action of the vapour from two sodium aluminates on clay and silica refractories at temperatures ranging from 900° to 1,200° C. is described. At all temperatures in this range the more aluminous materials showed less increases in weight than the fireclay and these in turn less than the siliceous and silica refractories. On the other hand, using sodium carbonate as a source of alkali vapour, silica materials showed smaller increases in weight than the fireclay products.

The Action of Slags on Refractory Materials.—The importance of this subject is self-evident to all users of refractory materials. It is difficult to assess the slag resisting characteristics of refractory materials; the conditions of service are so variable. Many slag tests have been devised and applied to the study of specific problems. The aim of the present investigation has been the better understanding of the fundamentals of slag action rather than the immediate improvement of methods of testing. For this reason the results obtained by three contrasting methods of testing have been correlated, and at the same time a thorough study made with the petrological microscope of the specimens resulting from the tests. Four lime-alumina-silica slags and a selection of silica, clay and aluminous refractories have been used in the work.

The first test method consists in measuring the refractoriness of a range of mixtures of powdered slag and brick. The second measures the extent of corrosion and penetration when a standard cylinder of compressed slag is melted under specified conditions on the upper surface of the test bricks. The third method aims at measuring the extent of erosion obtained by injecting powdered slag into a blast flame impinging on the test bricks under standard conditions.

The refractoriness brick-slag-composition curves obtained by the first method have been largely correlated with the data of the lime-alumina-silica diagram. A marked feature in all the curves is a relatively low minimum temperature of softening, ranging only from 1,140° to 1,200° C. despite a wide variation in the composition of the bricks. In the second method, interaction involving liquefaction occurs between the slag and the brick at about the temperature of minimum melting, as disclosed in the first test method. Microscopic examination of the samples has shown that in most cases anorthite (lime felspar) crystals are formed by the continued action of this liquid on the brick. The residual melt penetrates further into the brick. This liquid conduces to the formation of mullite in all but the highly siliceous materials. Anorthite is not formed with the silica bricks which as a class show marked penetration. Indications of an order of merit in the fireclay and aluminous bricks have been obtained from measurements of the depth of corrosion and of penetration. On the basis of the results of the slag erosion test tentative orders of merit have been assigned to the bricks, which, however, fall into two non-comparable categories—the silica bricks and the remainder. In this test two of the slags consisting mainly of gehlenite differentiate themselves from the two other slags which approach more to calcium orthosilicate in composition.

The Refractoriness-under-Load Test.—Previous reports on this subject have been concerned with two variants of the test which are in common use. The first may be described as the constant load—rising temperature test. Expansion-deformation-temperature curves are used to characterize the behaviour of the test-piece. The second may be described as the constant load—maintained temperature test. Expansion-deformation-time curves are used in this case to record the behaviour of the materials. These tests have formed the basis of contributions on this subject to the 25th, 26th and 27th Reports. A third variant, the maintained temperature—increasing load test, forms the subject of this year's contribution. Deformation-load-time curves have been used to record the behaviour of the materials tested. For firebricks the type of information obtained is analogous to that given by the rising temperature type of test. Different results are obtained, however, dependent on the rate of increase of loading, so that for routine testing purposes this factor would require to be standardized.

The Tridymitization of Silica Bricks.—Silica bricks of high cristobalite content suffer from the disability of a large and rapid expansion at about 220° C. due to the change from the α to the β form of this mineral. The corresponding effect with tridymite involves much less change in volume. The effect of additions of sodium and calcium phosphate to silica brick batches has been investigated to ascertain whether conversion of quartz to tridymite rather than cristobalite is favoured. Sodium phosphate gave indications of increasing the content of tridymite, but calcium phosphate tended to favour the formation of cristobalite.

High Porosity Sillimanite Materials.—The properties of some sillimanite products of high porosity prepared in the laboratory have been investigated. The porosity was increased (*a*) by introducing various proportions of fine anthracite into the mix and burning it away when the product was fired; and (*b*) by introducing various proportions of aluminium powder and hydrochloric acid into the plastic material which was thus bloated before firing. Some of the products possessed a porosity of about 70 per cent. and showed only slight subsidence under a light load at 1,350° C. The experiments were made with the object of developing materials of high refractoriness but low heat capacity and thermal conductivity.

Clay Bonded Silica Refractories in Segmental Horizontal Retorts.—Mr. A. Edwards contributes an important Paper in which the behaviour of retorts built with a clay-bonded siliceous material (91 to 92 per cent. SiO_2; 5 to 6 per cent. Al_2O_3) is compared with retorts in the rest of the house constructed in lime-bonded silica. The clay-bonded retorts were found to be freer from leakage and did not develop the erosion of the floor segments between four and seven feet from the mouthpiece typical of the lime-bonded silica material. The greater gas tightness was found to be due to the glazing of the inside and outside of the retort surfaces with a brown slag. This slag eventually caused trouble by running down and blocking the producer gas nostrils. Modifications of design and the use of different materials for different parts of the setting are suggested as means by which this latter disadvantage may be overcome.

A Tribute to Dr. J. W. Mellor.

The PRESIDENT: Before I ask Mr. Grogono to introduce the 28th Report of the Refractory Materials Joint Committee I should like to make a brief reference to Dr. Mellor, who, you will be very sorry to hear, is seriously ill. Dr. Mellor's first association with the Gas Industry began in the year 1908, at a time when data on the properties of fireclay and refractory materials generally were very scanty. Dr. Mellor had then just recently been appointed to organize the teaching of ceramics in the Pottery district and to enquire into the behaviour of refractory materials. Supported by the Gas Industry, he set to work at once to investigate the many problems involved. His work has been of inestimable value to the Gas Industry and, indeed, to all other industries using refractories.

The development of this work led, in 1920, to the formation of the British Refractories Research Association, to which he was appointed the first Director. The work of the Association was carried on in temporary buildings at the North Staffordshire Technical College until 1934, when the Association acquired its new premises, which were appropriately named "The Mellor Laboratories," in recognition of the work done by its first Director. Dr. Mellor retired from the Directorship of the Association in April of this year and was appointed its first President.

He has a charming personality, as all those who have worked with him can testify, and—perhaps quite as important—a keen sense of humour. In his retirement he may find time to let us have some more of his delightful caricatures and perhaps another volume of "Uncle Joe's Nonsense," which I am sure many of you have read.

The results of Dr. Mellor's work will always live in the Gas Industry, and I know it will be your wish to express to him our appreciation of all he has done and our hopes for a speedy recovery from his illness.

Mr. W. GROGONO and Mr. A. T. GREEN introduced the Report.

Discussion.

Mr. E. F. KEABLE (Gorleston and Southtown): At present carrying out minor repairs to our Woodall-Duckham continuous vertical silica retorts, we have discovered conditions probably not previously encountered. I have been asked, therefore, by my Chairman, Mr. Henry Woodall, and our Contractors, to lay the facts before you. It is only about ten days since the trouble came to light, so you will appreciate that there has been little time in which to deal with the matter exhaustively. The plant was completed in July, 1929, together with waste-heat boiler, and a section put to work. These retorts were shut down in November, 1936, having, in rotation, completed about 7½ years' working. This installation was augmented in 1933 with plant for increasing surplus steam output. Following the putting to work of the augmentation plant, deposits of dust in the boiler tubes became troublesome, and daily cleaning of these became necessary. This trouble was investigated and found to be primarily due to the high sodium chloride content of the coal—viz., 0·66 per cent. The boiler tube deposits were found to consist largely of sodium sulphate, together with some iron sul-

phate and fuel ash. The conclusions arrived at with regard to the sequence of happenings leading up to the formation of the deposits in the boiler tubes were as follows: A considerable proportion of sodium chloride (which has a melting point of 801° C. and volatilizes at higher temperatures) present in the coal remaining in the coke after carbonization, was subsequently liberated in the producer gas when the coke was used as fuel in the producers. This is due to the fact that coke is raised to a higher temperature during combustion in the producer than during carbonization in the retort. During the combustion of the producer gas in the heating flues of the retorts, the sulphur present would combine with the sodium chloride producing sodium sulphate and hydrochloric acid. Some of the sodium sulphate would be absorbed by the retort brickwork, some would be deposited in the flues at the bottom of the setting, and the remainder would be gradually deposited in the waste gas flue, boiler, and chimney. At the bottom of the combustion flues deposits of practically pure sodium sulphate were found during the investigation.

In view of the fact that the same type of coal had been used in the retorts from the time the plant was put into operation, it was thought desirable to work at somewhat lower temperatures, when the results of the investigation became known. This was done with the object of safeguarding the retort brickwork, as the extent of alkali absorption by the brickwork was not known, and could not be ascertained without shutting down the working retorts. From the beginning of 1934 the sodium chloride content of the coals was reduced by mixing 50 per cent. of another coal having a lower salt content—namely, 0·1 per cent. Making a careful examination of the retort brickwork during the repairs at the latter end of October of this year, the following conditions were found:

Top Silica Work, Combustion Zone Level.—Considerable erosion of the flue side of the retort face bricks had occurred, due, apparently, to the solution of the exposed surface of the bricks by alkali derived from the salt in the coal. The surface of the brickwork was smooth and glazed. The penetration of the fluxed material into the brick was apparently slight, owing, it would seem, to the protection afforded by the filling of the surface pores by the flux.

Silica Work at Lower End of Retorts, Lowest Temperature Zone.—The panel bricks constituting the bottom 12 in. or so of the retort wall had expanded in thickness from the original 4½ in. to 5 in., or about 11 per cent. The whole of this expansion had taken place on the flue side of the brick. The midribs had expanded in depth, horizontally, as much as 22 per cent., and in thickness by 33 per cent. These excessive expansions had caused considerable disintegration of the flue side of the bricks. By way of comparison with the bricks at the top of the retorts, little or no erosion had taken place at the lower end, the temperature being too low for fluxing to occur. Apparently the expansion of the flue side of the bricks was due to the absorption of alkali vapour from the waste gases. The behaviour of the bricks at the lower end of the retorts is thus somewhat similar to that of silica refractories exposed to alkali vapour, as mentioned in the Report.

Silica Work about Three to Four Feet above the Bottom of the Silica Zone.—The solid 3 in. retort wall bricks in this zone present a different appearance from those in either the top or bottom of the silica work. On the flue side of the bricks in this zone the surface has become semi-fused, and the penetration of alkali extends about 1¼ in. into the brick with the formation of a well-defined band, saturated with greenish glass. It is remarkable, however, that under the conditions of attack at this zone very little expansion of the brick has taken place, and very little erosion of the surface. The silica material in this zone (from the check dampers upwards) is good for a further term of from three to four years' working before repairs become necessary. The green colorization of the débris found in the bottom horizontal waste gas flue is green glass produced by a combination of silica, lime, alkali and a trace of iron oxide, derived from fuel ash. In those installations where coals having a low salt content are used, and when the carbonizing temperatures are high, the majority of the salt is liberated inside the retorts, and alkali attack, if any, takes place on the cool side instead of the flue side of the retort wall. The conditions at our Undertaking, up to the beginning of 1934, when another coal was introduced, were unique in that one coal only was carbonized, and it so happened that it was abnormally high in salt content. The consequent trouble with the cleaning of the boiler tubes, and the behaviour of the silica, is also unique.

The sodium chloride content of coals to be carbonized must receive more careful consideration in the future, and it would not be unreasonable to demand that the total sodium chloride content of coals used by our Industry should not exceed 0·2 per cent. in any consignment, and should not average more than 0·1 per cent. When dealing with our initial trouble in 1933, it was found that in some deliveries the total sodium chloride content was as high as 0·85 per cent., and the average over a long period 0·66 per cent. Now that the effect upon silica has been brought to light, in addition to keeping a more careful watch upon our coal supplies, doubtless our Refractory Materials Joint Committee will give the matter under review closer investigation. To this end, we still have more retorts to repair, in which we expect to find the same trouble, and samples of any materials removed during such work will be available should our Research Department need them.

Clay-Bonded Silica.

Mr. A. EDWARDS (Gas Light and Coke): Part IV of the Report embodies observations made at Beckton upon the durability of a type of silica material containing a proportion of clay built into segmental horizontal retorts. Beckton is the home of the straight silica lime bonded segmental retort set with straight silica cement, the alumina content throughout being less than 2 per cent. The technique developed after a series of costly experiments was fully discussed in a Paper by Mr. Hay with an appendix by myself given some years ago before the Southern Association of Gas Engineers and Managers. We were driven by the failure of materials containing clay to limit the alumina content to 2 per cent., or that naturally occluded in the crystalline silica rock. Clay or aluminium silicate is able to react with the inorganic constituents of the coal—the most prominent being volatile iron compounds and iron oxide—to form low melting masses which ultimately lead to open joints and holes. We were asked to try a silica material containing naturally a small quantity of clay—5 to 6 per cent. Al_2O_3—and much unconverted quartz, a material which would not pass the silica specification. Much to our surprise the retorts maintained their shape at combustion chamber temperatures averaging 1,360° C. No disadvantages appeared from the further conversion of the quartz.

Under the routine system of testing by air pressure the retorts proved to be less leaky than those of straight silica, and there was less erosion of the floor tiles. This aspect of the matter was reported to the Refractory Materials Committee with a request for experimental work to be undertaken to decide whether the clay bonded silica was more resistant to abrasion than lime bonded silica. Mr. Green at the time was interested in the performance of the material, and it is due to his request that the notes constituting section IV are included in the Report.

The gas tightness was obvious to the eye when the cold retorts were examined. The surfaces were covered by a glassy slag which sealed all joints, obviously the effect of the combined alumina. There was no slag on the straight silica.

One might ask why holes did not develop as in the case of our early silica settings. The answer is believed to be in the use of silica cement containing clay to joint straight silica shapes. It is a fact that an 88 to 90 per cent. SiO_2 cement vanished completely from some of the cross-wall joints. There is little doubt that combination with the inorganic constituents of the coal formed liquid slag, which eventually dissolved the silica grains, and was absorbed by the porous silica shapes, like a sponge absorbs water.

In the valuable section of the Report dealing with the action of slags on refractory materials, admixtures of the two formed eutectics of low melting point within the narrow range of 1,140° to 1,200° C., the point to observe is that in any slag attack the constituent first formed is the eutectic with the minimum melting point which will approximate to the range mentioned, and amply justifies our views.

With the semi-silica material under discussion the mass and surfaces of the sections themselves participate in the general slag attack, and the pores fill to such an extent that absorption of liquefying cement does not take place. The action is eventually arrested by the thickness of the film which tends to freeze the further it penetrates. Wastage can only occur by actual flow from the vertical surfaces to lower points, the slag eventually blocking up the producer gas nostrils. It is this action which will seriously limit the use of clay bonded silica unless the slag is side-tracked as suggested in the note.

The outcome of the trial suggests that subject to a satisfactory disposal of the slag flow, a better all-round service may be expected from a clay bonded silica material when confined to the construction of the actual retort itself. Supporting cross-walls should be in straight silica set with straight silica cement.

Those of you who have faith in moulded siliceous retorts may find that the substitution of clay bonded silica segmental retorts will give equal, and possibly increased yields, with an extended life, at a fraction of the cost for maintenance.

Mr. C. R. F. THRELFALL: There are lessons to be learned

from this Report; the first is that there is much dissatisfaction with all the refractory materials which you employ. Practically every investigation in this Report is directed to trying to improve something which is essentially unsatisfactory. This is the 28th Report of the Refractory Materials Joint Committee and I think it does mark a definite epoch. I am sorry indeed that it also marks the retirement of Dr. Mellor. At the same time it marks the enthronement of my friend Mr. Green, about whose technical ability this Report leaves us in no doubt. It also marks the appearance of a Paper of what one might call extra-mural origin for it includes a Paper by Mr. Edwards which, I think, may be said to be the first contribution that this Research Association has ever received from an outside source. I do not agree with all Mr. Edwards' remarks but naturally we appreciate Mr. Edwards' difficulties. The research that is going on will never really achieve the value which we expect because you will notice that all these Papers refer mainly to chemistry and physics; none of them refer to what I call the mechanics of furnace construction or the mechanics of brick making. That is a matter which should undoubtedly be undertaken by the Research Association for it is just as important that we should know the simple mechanics of these things as that we should know their chemistry and their physics.

Alkali Attack.

Mr. PETER LLOYD (Gas Light and Coke): The work of Mr. Green and the Refractories Research Association is not only of value to the manufacturing side of the Industry but also to the utilization side. In particular, we on the industrial side are looking more and more to the help which we know we can get from him. As one instance of the work which is of assistance to us I might quote this case which has been so widely discussed of the attack of alkali vapour on refractory materials. Although this work was obviously started from the point of view of gas manufacture, similar problems are, in fact, encountered in furnace design, especially in the heating of certain salt baths for the heat treatment of metals. It is not a matter into which I can go in any detail now but it is quite clear from the substance of this Report that Mr. Green's work on this subject will be of great assistance to us. We also hope in the future to obtain much greater assistance in connection with the production of porous refractories which are now so largely used in furnace building, and also in connection with the supply of high conductivity refractories for recuperator tubes and moulds.

Mr. Clews Replies.

Mr. F. H. CLEWS: My part, I believe, is not so much to reply to the discussion as I think there are very few points on which issue could be raised, but I should like to give a brief outline of the work which has been coming from our laboratory at Shelton on the question of alkali attack of refractory materials. This has been in progress now for a number of years and it has been tackled from a number of different points of view. The points of view from which it has been tackled depend in the first place on the source of the alkali—the particular salt which may be used as the source of the alkali vapour. One particular batch of experiments has been connected with the effects due to alkali chlorides—potassium and sodium chlorides—and our work has shown that in regard to the reaction of the alkali part of the salt, silica materials are much more resistant than the ordinary normal fireclay materials. That distinction is more pronounced when the atmosphere in which the reaction takes place is dry. It is still there but not quite so pronounced if steam is present in the reacting atmosphere. Another feature which has been noticed with regard to the action of alkali chlorides on refractories, both fireclay and silica, is a very noticeable expansion. In the Laboratory expansions of the order of 4 per cent. in length have been observed in a period of about 100 hours. It seems fairly clear from the results that there are two conflicting tendencies. There is the reaction which tends to bring about contraction, and superposed on that is a reaction tending to bring about an expansion depending on the conditions, the temperature of the alkali and other factors which we do not really understand at the moment. So we get a balance between contraction and expansion. That the 4 per cent. expansion is no mere academic matter I think the specimen on exhibit this afternoon will bear ample testimony to, because you can get enormous strains set up by quite a small expansion. Another factor probably related to the linear expansion is a reduction of strength which may accompany the effect of alkali salt. That is noticeable and it has, to a limited extent, been investigated quantitatively. Fireclay materials are reduced in strength on exposure to alkali chlorides and, in fact, one particular specimen was reduced to a heap of grains merely by such exposure.

Another effect due to alkali chloride is that iron compounds tend to be volatilized from the body of the brick and become concentrated in some particular locality in the form of oxides. It is suggested that such concentrations of iron oxide may have deleterious results, for example, from the point of view of hydrocarbon disintegration or CO disintegration and that there might be deleterious effects due to slag action upon the chlorides. We also have carried out experiments, and some are in progress, on sodium carbonate, and in certain respects sodium carbonate shows a similarity in its behaviour to sodium chloride. It shows the phenomenon of attacking the fireclay materials apparently in the vapour state more readily than silica, but it does not, so far as we can see, indicate an expansion phenomenon. On the other hand, if you use another source of alkali, the potash class or caustic soda or the vapour from sodium aluminate, then another type of action seems to be involved and we find that the silica materials are those which are the more readily attacked. Therefore, the problem is quite complex and demands attention from quite a variety of points of view. We hope that our work as it continues will bring results of interest to the Industry.

3rd Report of the Research Executive Committee; 1936-37

Communication No. 165

RESEARCH EXECUTIVE COMMITTEE

The members of the Research Executive Committee of The Institution of Gas Engineers for 1936-37 were:

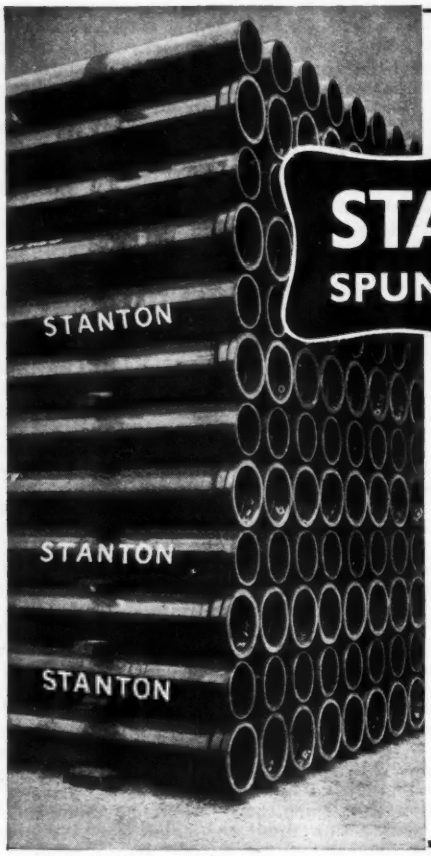
E. V. Evans, O.B.E., F.I.C. (*Chairman*); H. C. Smith, M.Inst.C.E. (*Vice-Chairman*); Stephen Lacey, B.Sc., M.Inst.C.E. (*Honorary Secretary*); H. Hollings, M.Sc.; H. D. Madden, M.Inst.C.E., M.I.Mech.E.; C. A. Masterman, M.A., M.I.Mech.E., F.I.C.; T. F. E. Rhead, M.Sc., F.I.C.; E. W. Smith, C.B.E., D.Sc., F.I.C.; the President, the two Vice-Presidents, and the Honorary Secretary of the Institution (*ex-officio*).

On 6th July, 1937, Mr. F. P. Tarratt resigned the Chairmanship of the Research Executive Committee, a position he had held since the inception of the Committee on 5th October, 1934. The thanks of the Committee are due to Mr. Tarratt for the service rendered by him as its Chairman. He has been succeeded by Mr. E. V. Evans as Chairman of the Committee.

A visit has been paid to Germany by the Secretary of the Institution and Dr. F. J. Dent (Research Chemist) to inspect a plant in regular operation supplying the whole of the gas requirements of a town of 60,000 inhabitants by the complete gasification of brown coal, using oxygen and high pressure. The process presents many interesting features, but, owing to the difference in the nature and properties of brown coal and bituminous coal, more information is being obtained as to the behaviour of various types of coal and other carbonaceous materials when gasified with oxygen and steam under high pressure.

Technical developments at home and overseas continue to be watched and investigated. There is no material development to report in the introduction on a commercial scale of processes for the removal of carbon monoxide from town gas, the position regarding which still appears to be essentially the same as outlined in the 1st Report of the Research Executive Committee; 1934-35. (*Communication No.* 120; p. 6.)

Close contact is being maintained between the Research Executive Committee and the Industrial Gas Centres Committee regarding research and development work. The Chairman of the Industrial Gas Centres Committee has met the Research Executive Committee, at its invitation, and has discussed with it the desirability of the initiation, by the Research Executive Committee, of investigations of



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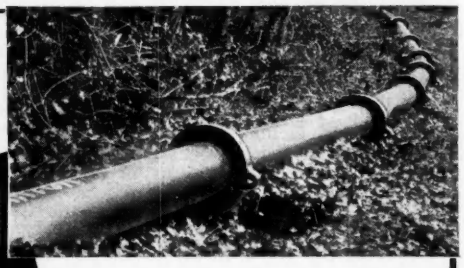

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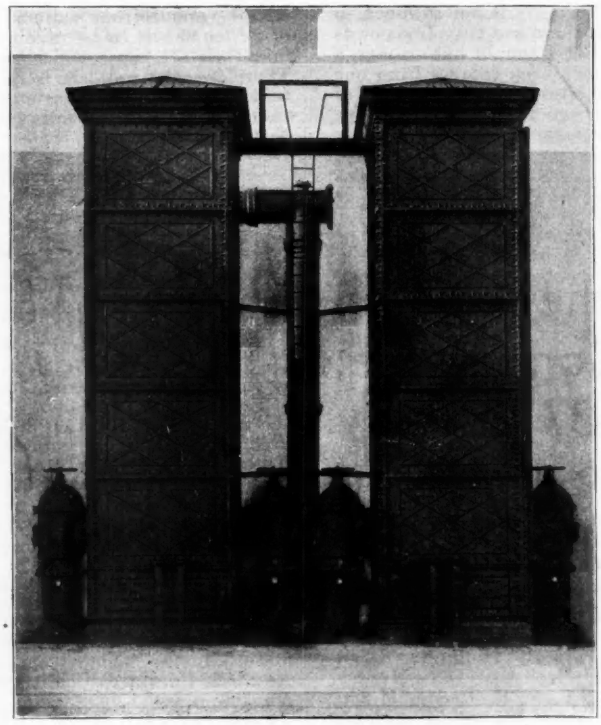

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problems concerning methods and appliances for the utilization of gas in industrial processes.

A Sub-Committee of the Research Executive Committee is examining the possibility of arriving at a formula—sufficiently accurate for practical purposes—to enable Gas Undertakings to reduce to comparable conditions of temperature and pressure gas made as registered by Station Meter and gas sold as measured by consumers' Meters.

The Institution continues to support the investigations of the Association of British Chemical Manufacturers into Methods for the Detection of Toxic Gases in Industry and the Standardization of Performance Tests for Industrial Respirators. The first results of these investigations have recently been published by the Department of Scientific and Industrial Research as "Methods for the Detection of Toxic Gases in Industry. Leaflet No. 1. Hydrogen Sulphide."

The Research Executive Committee has been materially assisted in its consideration of research problems affecting the Gas Industry by discussions at the annual meeting of the Advisory Committee on Research and by valuable Memoranda and Reports which have been received from various sources and of which acknowledgment is made.

Kindred Organizations

The Institution co-operates in the work of the Joint Committee on Materials and their Testing of Technical Institutions and Societies in Great Britain, the object of which is, *inter alia*, to promote joint discussions on matters relating to materials and their testing and to assist co-operating Institutions and Societies in the presentation of a Paper or Papers relating thereto. It was also associated with the International Congress of the International Association for Testing Materials, held in London from 19th to 24th April, 1937.

The Institution of Gas Engineers continues, through the Gas Industry Committee, Technical Committees, and otherwise, to co-operate with the British Standards Institution in the preparation of British Standard Specifications. Its thanks are due to its representatives for their assistance and time given to this work.

Advisory Committee on Research

The membership of the Advisory Committee on Research for 1936-37 was as follows:—

President (Chairman), the two Vice-Presidents, Honorary Secretary, members of the Research Executive Committee, Chairmen of nine Technical Committees of the Institution and the Livesey Professor, all *ex officio:*

H. C. Smith, M.Inst.C.E. (*Chairman*); E. V. Evans, O.B.E., F.I.C. (*Vice-Chairman*); Stephen Lacey, B.Sc., M.Inst.C.E. (*Honorary Secretary*); Charles F. Botley, M.Inst.C.E.; Prof. John W. Cobb, C.B.E., B.Sc., F.I.C.; George Dixon, B.Eng., M.Inst.C.E.; H. J. Escreet, B.Sc. Eng.; Walter Grogono; Thomas Hardie; H. Hollings, M.Sc.; H. D. Madden, M.Inst.C.E., M.I.Mech.E.; C. A. Masterman, M.A., M.I.Mech.E., F.I.C.; T. F. E. Rhead, M.Sc., F.I.C.; Robert Robertson, M.Inst.C.E.; Charles S. Shapley, M.I.Mech.E.; E. W. Smith, C.B.E., D.Sc., F.I.C.; John Terrace, M.Inst.C.E.

Representatives of Government and University Fuel Research and others having a special interest in Research:

Prof. W. A. Bone, D.Sc., Ph.D., F.R.S.; H. T. Calvert, M.B.E., D.Sc., Ph.D.; Charles C. Carpenter, C.B.E., D.Sc.; Sir Christopher Clayton, Kt., C.B.E., J.P.; W. A. Damon, B.Sc.; Margaret Fishenden, D.Sc.; Sir Francis Goodenough, Kt., C.B.E.; A. T. Green, F.I.C.; Sir Harold Hartley, Kt., C.B.E., M.Sc., F.R.S.; Harold Hartley, D.Sc.; James Jamieson; Frank H. Jones; Prof. C. H. Lander, C.B.E., D.Sc.; J. W. McLusky, M.I.Mech.E.; J. W. Mellor, D.Sc., F.R.S.; Prof. Sir Gilbert Morgan, Kt., O.B.E., D.Sc., F.R.S.; A. Parker, D.Sc.; F. B. Richards, M.B.E.; F. S. Sinnatt, C.B., M.B.E., D.Sc.; Sir Frank E. Smith, K.C.B., C.B.E., D.Sc., Sec.R.S.; Prof. Arthur Smithells, C.M.G., D.Sc., F.R.S.; Frank P. Tarratt, M.Inst.C.E.; J. W. T. Walsh, D.Sc.; C. M. Walter, D.Sc.; Sir Frederick J. West, Kt., C.B.E., J.P.; Henry Woodall, J.P.

National Gas Council Nominees:

President (*ex-officio*): Sir David Milne-Watson, Bt., M.A., D.L., LL.D.; A. W. Smith; W. J. Sandeman.

British Commercial Gas Association Nominees:

President (*ex officio*): Councillor W. P. Jackson; T. P. Ridley; J. Sandon Stubbs.

Society of British Gas Industries Nominees:

Chairman (*ex officio*): R. J. Rogers; Colonel O. B. F. Planck, D.S.O.; H. M. Thornton, J.P.

The Advisory Committee on Research held its first annual Meeting on 26th November, 1936.

The Committee was appointed by the Council, in accordance with a Scheme of Research and Technical Organization, which became operative on 8th November, 1934. It meets to receive and consider the Annual Report of the Research Executive Committee and to discuss, on broad lines, the research requirements of the Gas Industry. For the guidance of the Research Executive Committee, it reviews the trend of technical development in all its aspects, but it has no responsibility for the details of research, personnel, finance or organization.

Gas Works Safety Rules Committee

The membership of the Gas Works Safety Rules Committee is as follows:—

F. M. Birks, O.B.E. (*Chairman*); H. E. Bloor, B.Sc., B.Eng.; J. E. Blundell; J. R. Bradshaw, B.Sc.; J. M. Campbell, J.P.; Thomas Carmichael, M.Inst.C.E., M.I.Mech.E.; Thomas Hardie; James Jamieson; J. W. Napier; Charles S. Shapley, M.I.Mech.E.; H. C. Smith, M.Inst.C.E.; E. G. Stewart; Frank P. Tarratt, M.Inst.C.E.; E. B. Tomlinson, M.Inst.C.E.; F. H. Vince, M.I.Mech.E.; the President, the two Vice-Presidents and the Honorary Secretary of the Institution (*ex officio*).

The Gas Works Safety Rules Committee has been appointed by the Council to deal with all matters relating to Rules for the Safe Operation of Gas Works. Mr. F. M. Birks has been elected Chairman of the Committee and the membership comprises the members of the Gasholder Committee and of the Purifiers Committee.

The Committee has held its first Meeting and is considering, *inter alia*, technical problems (other than lighting, which is dealt with by the Joint Lighting Committee) relating to Air Raid Precautions in respect of Gas Undertakings.

Joint Lighting Committee

The membership of the Joint Lighting Committee for 1936-37 was as follows:

Stephen Lacey, B.Sc., M.Inst.C.E. (*Chairman*); A. Maurice Bell; W. J. A. Butterfield, M.A., F.I.C.; J. G. Clark; W. J. G. Davey, B.Sc.; Harold Davies; J. E. Davis; George Dixon, B.Eng., M.Inst.C.E.; W. R. Edgar; E. V. Evans, O.B.E., F.I.C.; Colonel C. J. Falk; J. Weatherall Foreman; James Jamieson; F. J. Gould; J. R. Hepple; A. G. Higgins; A. L. Holton; J. H. G. Horstmann; C. H. A. Kempton; A. R. McGibbon; C. A. Masterman, M.A., M.I.Mech.E., F.I.C.; R. J. Rogers; F. C. Smith; W. L. S. Spinks; H. R. Stevenson; Philip H. Sugg; Robert Watson; C. I. Winstone; the President, the two Vice-Presidents and the Honorary Secretary of the Institution (*ex officio*).

The membership of the Committee has been reviewed and increased to include greater representation of provincial Gas Undertakings and of the Lighting Section of the Society of British Gas Industries.

The Committee, which has met regularly throughout the year, has continued to examine, with the assistance of its Technical Sub-Committee, the possible initiation of useful research into problems relating to gas lighting, with particular reference to increasing the efficiency of gas burners, mantles and switches. The Technical Sub-Committee has continued its discussion with representatives of the makers of domestic gas burners of technical problems relating to domestic gas lamp burner design and has tested samples of burners submitted by the makers.

The Committee has also continued to examine means of providing for the instantaneous extinction of gas street lamps in the event of aerial attack and has tested a variety of special devices for that purpose. It is of the opinion that, whilst in the case of new installations or of relatively simple distribution networks, control by pressure wave can be satisfactory, in the more complex of existing networks pressure wave control may be impracticable. Alternative methods of control are therefore being investigated. The difficulties that may be met with, however, depending upon local conditions, apply equally or even more in many cases, to other types of illumination.

The Committee has maintained close contact with the Air Raid Precautions Department of the Home Office, representatives of which have discussed with the Committee precautionary measures depending upon instantaneous extinction of street lamps, permanent extinction of street lamps, dimmed lighting and/or shaded street lamps. Up to the present, however, the Home Office has not defined its defence policy or its requirements regarding street lighting in times of national emergency.

Members of the Committee have attended, by invitation, practical trials made by the Home Office of different systems of dimmed and screened street lamps, and Mr. F. C. Smith has accepted the invitation of the Air Raid Precautions Department of the Home Office to become a member of its Lighting Committee, which is investigating the forms of illumination which could be allowed in time of war, particularly in streets and industrial premises.

The *ad hoc* Committee, set up at the request of the

British Gas Federation to consider the whole problem of Public Lighting, and composed of representatives of the Joint Lighting Committee and of the Lighting Section of the Society of British Gas Industries, has presented its final Report, which has been approved by the Council of the Federation. Particular attention is directed therein to the desirability of all Gas Undertakings extending and maintaining Public Lighting by Gas and to the facilities afforded by the National Organizations for supplying information and advice to Gas Undertakings seeking guidance regarding Gas Street Lighting problems.

The revision of the British Standard Specification for Street Lighting has been deferred pending the publication of the Final Report of the Departmental Committee on Street Lighting of the Ministry of Transport.

Meters Committee

The membership of the Meters Committee for 1936-37 was as follows:

John Terrace, M.Inst.C.E. (*Chairman*); H. E. Bennet, M.C.; R. J. H. Clark; C. M. Croft, J.P., M.Inst.C.E., M.I.Mech.E.; H. W. Hodgson; Stephen Lacey, B.Sc., M.Inst.C.E.; L. F. McLeod, O.B.E.; J. W. McLusky, M.I.Mech.E.; R. G. Marsh; C. A. Masterman, M.A., M.I.Mech.E., F.I.C.; C. H. Rutter, M.Inst.C.E.; W. J. Sandeman; Charles S. Shapley, M.I.Mech.E.; Frank P. Tarratt, M.Inst.C.E.; the President, the two Vice-Presidents, and the Honorary Secretary of the Institution (*ex-officio*).

In connexion with the previously published 1st and 2nd Reports of the Meters Committee; The Institution of Gas Engineers' Specification for Gas Meters for Domestic Consumers (*Communication No.* 126) attention is directed to the recent publication by the British Standards Institution of British Standard Specification No. 746 (1937) for Gas Meter Unions, prepared at the request of and in collaboration with the Meters Committee.

Purifiers Committee

The membership of the Purifiers Committee for 1936-37 was as follows:

Charles S. Shapley, M.I.Mech.E. (*Chairman*); J. E. Blundell, M.Inst.C.E.; Thomas Carmichael, M.Inst.C.E., M.I.Mech.E.; J. W. Napier; E. G. Stewart; Frank P. Tarratt, M.Inst.C.E.; E. B. Tomlinson, M.Inst.C.E.; F. H. Vince, M.I.Mech.E.; the President, the two Vice-Presidents, and the Honorary Secretary of the Institution (*ex-officio*).

The Purifiers Committee has progressed with the preparation, in conjunction with the Home Office, of Voluntary Rules for the Safe Operation of Purifiers.

The Committee has now been merged in the newly-formed Gas Works Safety Rules Committee, to which the completion for publication of the above-mentioned Voluntary Rules has been referred. The thanks of the Research Executive Committee are due to Mr. C. S. Shapley for the service rendered by him as Chairman of the Purifiers Committee.

Discussion.

The President: This item on the Agenda is intended for the consideration of matters referred to in the 3rd Report of the Research Executive Committee and not dealt with in the separately published Communications for which time for discussion has previously been provided during the meeting, and also for the review and general discussion of, and the submission and consideration of proposals for, gas research and investigation and technical work. It is an item we have had on the Agenda since the commencement of these Autumn Meetings or at any rate since the date when we reorganized the Research Committee of the Institution, but I am afraid it is an item on the Agenda which has never given us much meat. Dr. Braunholtz, our Secretary, conceived the idea that as we must all be getting rather stodgy ourselves, on this occasion it would be a good idea if we went outside the Institution and asked someone who was keenly interested in research to come along and make some suggestions for us. He is only just in time in going outside the Institution because we have asked Sir Harold Hartley, who has kindly consented to come and talk to us. Sir Harold is Chairman of the Fuel Research Board, he is a Director of the Gas Light and Coke Company, and he is Vice-President of the L.M.S. Railway. In all these capacities he is keenly interested in research and in the application of research to industry. In fact I do not honestly think he is interested in research unless he can see the industrial application of it, but, as I say, the Secretary is only just in time in getting someone from outside the Institution to talk to us because the next item on the Agenda is to receive a Report of the Ballot for the election of an Honorary Member, members, associate members, and associates. I have had the advantage of having a private view of this Report of the Scrutineers and I am very glad indeed to be able to tell you that the gentleman who is now going to address you has just been elected an Honorary Member of this Institution. Although we do not ask any Honorary Member to pay any subscription we do expect them to pay for their footing, and I am going to ask Sir Harold Hartley to talk to us now.

Sir Harold Hartley, F.R.S.: May I first say how much I appreciate this great honour you have done me. After all, it is the greatest honour that anyone can receive in the Gas Industry to be given the honorary membership of this Institution. I have been connected with the Gas Industry, but, of course, my up-bringing was on the chemical, and not on the engineering, side. I have been connected with the Industry for fifteen or sixteen years and I know what a great part and what a very valuable part in the Industry this Institution plays and how in many ways it contributes to its efficiency. Therefore, I do appreciate very much indeed the honour you have done me.

I wish that I had come here to make my first appearance before you rather better prepared. Unfortunately I have been away and it was not possible for me to benefit by taking part in the discussions on the Papers. They are a very formidable quantity and I have not even had the time I would have liked to read them but I know what is interesting in a good many of them.

What I take it, Mr. President, you would like me to do —I cannot, as I say, do it as the result of very mature reflection—is to tell you my general impressions on looking through these Papers in relation to what I know of the research resources and the research problems of the Industry. I would first like to congratulate the Executive Research Committee on this very valuable series of communications which you have been considering because it seems to me that they do deal with a very large number of the problems with which you are faced. They deal, for instance, with a very large number of works problems, including that very important one, I think, to the future of the Industry, of better methods of purification so far as sulphur is concerned. They also deal with some vital problems in the matter of appliances, and then you have that Paper on the work at Leeds University on carbonizing under pressure, to which Mr. Evans has referred, and I should like to say that this valuable suggestion was accepted by the Fuel Research Board that we should have a Joint Committee to consider this problem which may have a very important bearing on the future of the Industry, on complete gasification and particularly carbonization under pressure. You have also considered that very interesting report by Dr. Dent and his colleagues and I would just like to say that we have not been quite as idle at the Fuel Research Station as you might have thought from his remarks. We have been studying this problem of complete gasification of non-caking coals and coals containing considerable quantities of volatile matter, and we have got some results on the large scale water gas plant which I hope will, before long, be communicated to the Institution. Perhaps I might roughly summarize them. We have found that by modifying the technique of the water gas process we can gasify coals containing up to 17 per cent. volatile matter in an ordinary plant and by the addition of a cracking chamber to the plant we can gasify coals containing 35 per cent. to 40 per cent. of volatile matter, the tar being completely gasified. We have studied a fair range of coals but the range of suitable coals has not yet been determined fully, but roughly speaking you may say that they must not integrate unduly in the bed, on the one hand, nor form masses of coke on the other. The second stage of this problem, the enriching of this gas for town purposes by converting a portion of it into paraffin hydrocarbons, we have also not been quite idle about. We have been studying, in the first instance in that case, the conversion of the mixed gases, by a modification of the Fischer-Tropsch process, to liquid hydrocarbons; but the study that we have been making also of catalysts will, I know, be of considerable value when we come on to the more immediate problems so far as you are concerned of their conversion into gaseous hydrocarbons. Therefore, I think our co-operation is proceeding on the lines which we anticipated so far as the Joint Committee is concerned and I hope before long, as I say, there will be a Paper which I think will be of interest to the Institution dealing with the work that is being done at the Fuel Research Station on the complete gasification of various types of coal.

Resources for Research.

One of the problems I was thinking over after looking at these Papers was what resources we have to draw upon for research in the Industry. One of the speakers this after-

noon, I think it was Mr. Green, said he was an individualist. Well, so am I, and I am a believer in having a number of units working at your problems. I always think that if you have a number of centres each, if I may say so, intellectually independent, you are much more likely to get new ideas and you are much more likely to get that sort of individual development on which, after all, progress in research depends. If you take the position at the moment as revealed in these Papers, you have the works going on at Leeds University under the Joint Committee of the University and the Institution; you have the work going on in our various panels; then you have the work going on under the various Joint Committees such, for instance, as the work being done by the Refractories Research Association; you have the work being done in the individual companies—both the companies making appliances and the companies making gas and coke—and then you have the Fuel Research Station, so that you have quite a number, and I think in that way the position is very satisfactory inasmuch as you have a number of these individual units at work.

Now, of course, the important part which the Institution can play is in the co-ordination of that work. You cannot coerce them, of course, but I have always found these research bodies extremely willing to co-operate and only too glad to know what are the outside views of the problems that they might be studying, because after all the value of their work depends very much on it having constant touch with its applications. I will take just one example. We have had one Paper by Dr. King and Mr. Jamieson which represents the closest co-operation between the Fuel Research Station and the City of Edinburgh Gas Department. That seems to me a function in which the Institution has a great part to play. In fact, I do not think there is any other body which can integrate all this work so well as the Institution, for there is no other body which has the same touch as the Institution has with every other branch of the Industry nor the same touch with all these outside research agencies. Moreover, there is no other body which can help to define so clearly the problems which are immediately before the Industry to study, and all these different investigations which are represented in the Papers which have been presented and, of course, the speeches which I have listened to this afternoon, leave no doubt whatever in our minds that what we need is a great deal more research, and that is a point which Sir Frank Heath touched upon at the luncheon on Tuesday. I think the optimistic side of that is that if you had had a meeting like this 10 years ago you would not have had anything like the amount of material to discuss, so that I am sure that great progress is being made. But I think it is important to make everybody realize that research necessarily is rather costly. Modern research, which requires a technique, is getting more refined, which means that the expenditure is necessarily bigger. Therefore, I think the endowment of research must be on a liberal scale. I should like to emphasize one point there particularly. The bulk of the work represented in the Communications before this meeting is directed to your immediate problems. The longest distance thing in these Communications is the work on carbonization under pressure. You cannot safeguard the future of the Industry by working only at the problems which you see immediately facing you, because things are moving so quickly nowadays and other industries are spending large sums of money on research and they are doing a great deal of fundamental research. Therefore, it is essential that the Gas Industry should be looking ahead and should take care that a sufficient proportion of money which is being spent on research should be spent on fundamental investigations. Of course, one difficulty when you are asking for money for that purpose is that you cannot point to the particular results which are going to accrue. If you could, however, you could hardly call it fundamental research. Mr. Green talked about the value of accidents in research. Of course, it is these unexpected things which crop up in fundamental research which may change the whole face of an Industry, and there I would like to make this plea for more fundamental research, and to follow up another point made by Mr. Green that, of course, you cannot insist on results in a definite time. He said it had taken him five years to lay an egg. It might have taken much longer and yet the egg might have been worth much more the cost of the work over that period. It is difficult to put this fundamental work on what you might call a commercial cost basis. It does mean faith in research and I think that faith proves itself justified.

There is just one other point I want to make where it seems to me the Institution has a valuable part to play and that is in making the application of research easier. It is no good just doing the work and getting the results embodied in a series of valuable Reports like those which have been presented at this meeting, unless you make the application easy. For big undertakings which have large engineering and scientific staffs, of course, the problem is simple but, after all, the strength of the Industry depends on the general strength of all its undertakings and when you come to the smaller undertakings it must be realized that it is much harder for them to make the adjustments and to apply the knowledge that is given to us in these Reports. Therefore, I would suggest that that is a function which this Institution might usefully perform.

May I thank you once again and say that I do most sincerely feel it is a great honour you have done me in electing me an Honorary Member of the Institution. It is very much appreciated.

The Research Luncheon

The Ninth Autumn Research Luncheon was held at the Savoy Hotel on Tuesday last, the PRESIDENT (Mr. Harold C. Smith) presiding over a large gathering which included representatives not only of the Gas Industry but of the allied industries and organizations, both technical and commercial.

After the toast of "The King" had been honoured, the PRESIDENT proposed "The Guests," and remarked that this luncheon provided the members of the Council of the Institution with an opportunity of giving thanks to everyone who had in any way helped to further the progress of the research work conducted by the Institution or its scheme of education. It also provided a brief interlude in the more serious business of the Autumn Meeting at which several valuable reports and Papers were being discussed.

Continuing, the President said they were sometimes criticized as an Institution for not producing more important results from their research work—something more spectacular, an entirely new method of producing or utilizing gas sufficiently staggering to become front page news in the popular daily Press—but he could hold out no hope of anything so sensational. While it was true that occasionally—very occasionally—a revolutionary discovery might be made by a research worker as the result of an accident—[laughter]—no co-operative research scheme would be justified which looked to such a cause for its results. They could only hope by patiently pursuing a definite plan of investigation eventually to reach conclusions which would be of assistance to the members and to the Gas Industry. The value of this work to the Industry would depend on how far individual gas undertakings made practical use of the results obtained by the research worker. No industry could afford to neglect research in some form or another whether it be technical research dealing with the production of an article, or market research dealing with its sale. Sir Harold Hartley, who among his many other activities was Chairman of the Fuel Research Board, speaking in Birmingham a few weeks ago, said that the best insurance policy for the future of an industry was research which would enable it to foresee future lines of development to solve its immediate problems and to improve and cheapen its products. The extent to which these objects could be brought to fulfilment, however, depended largely on the funds available. They could not expect to get out of research more than was put into it. The amount put in, in the case of the Gas Industry, was in his view amazingly small. The sum of money available for research from the contributions to the national funds of an undertaking having an output of 2,000 million cu.ft. per annum was approximately £50. For that sum there was available to the undertaking the fullest information resulting from the research work carried out by, and in conjunction with, the Institution. It did not need much imagination to see how much research the 2,000 million undertaking itself could do for £50 per annum! The same information was available to an undertaking making 100 million cu.ft. per

annum for a contribution, in this case, of £2 10s. towards research expenses. There was no secret about these figures. They could be calculated by anyone who wished to do so from published accounts. However, continued the President, he was not making an appeal for additional contributions for research. There were other organizations in the Industry which absorbed funds as well as The Institution of Gas Engineers, and the funds available were allocated between the national bodies in a manner which was considered to afford the greatest possible all-round benefit to the Industry. Nevertheless, he would like anyone who wished to criticize the results of the Institution's research work too severely to consider the matter from the point of view he had mentioned before doing so.

The question was, were they getting what they paid for, and, also, were they putting into practice the results of the investigations which were given to the Industry from time to time? The Institution of Gas Engineers could conduct research work, but it was only the individual gas undertakings which could take full advantage of it by putting it to some practical use.

After reference to a number of their guests on that occasion, the President coupled the Toast with the names of the Right Hon. the Earl of Dudley and Sir Frank E. Smith.

A Great Triumph.

Lord DUDLEY, responding to the Toast, said he very keenly appreciated the importance of The Institution of Gas Engineers and the wonderful work it was doing in regard to technical development and scientific research in the Industry. To the layman—and he spoke as a layman—the Gas Industry was as up-to-date as it was possible to be in regard to research and development and being able to give the British public the very latest, the very cheapest, and the very best gas appliances, in the widest possible sense. Great Britain in this respect stood second to none in the world. Indeed, he doubted very much whether there was any other nation in the world which was so up-to-date in this direction and it seemed obvious to him that in this great triumph The Institution of Gas Engineers must have played a very important rôle. Business men who had to face the rush of everyday life knew how difficult it was to keep abreast with day-to-day developments and they relied on Institutions of this kind in every industry to provide the latest developments and the latest practice. So far as the Gas Industry was concerned, the help of the Institution in that direction was invaluable.

Sir FRANK SMITH said he was very glad to be associated with the Earl of Dudley in responding to this Toast because it was in the area with which Lord Dudley was associated that the first industrial revolution was started. In the Gas Industry there appeared to be two schools of thought. There was one school of thought which said "Forward" and there was another which he would not say said "Back" but it rather said "Halt." He gathered this impression, as he thought any neutral person would, from reading the Report of the Executive Committee last year. There were people who said that while they did not advocate going back on research they did not advocate more research and they thought comparison with the electrical industry was not relevant and that it was somewhat misleading. There was a statement in the Report as to the amount of money being spent on co-operative research in the electrical industry, and it was put at between £40,000 and £50,000. However, he could give a fairly reliable estimate of what the electrical industry was spending on co-operative research—fundamental and otherwise—with the object of increasing the demand on the electrical industry and, in particular, dealing with one of their biggest problems, the distribution of electricity. It was £500,000 per annum, and it was increasing. He knew one firm alone which had spent £80,000 a year for five years in developing a single product.

Another matter affecting the Gas Industry, as he read the Report last year, was the asking of two questions: (1) Were they spending enough on research and (2) were they tackling research in the best way? He would have to leave them to answer these questions themselves. In his opinion, and he said it quite frankly, the Industry was not spending enough money on research. The Gas Industry, unlike the electrical industry, was not faced with the same problem. Coal was its raw material, and that was not a single entity, because it was rich in compounds, including carbon, hydrates, and many other things as well as coke, tar, and benzole, all of which could be converted into other products of great value and for many of which there was a very great demand. Therefore, the extent to which the Gas Industry was able to produce new products economically, and the extent to which these products were to be transported to the consumer, depended entirely upon the acquisition of knowledge and the application of that knowledge. Indeed, one must look upon the Gas Industry as being in the future not only the Gas Industry but also associated with a very big chemical industry in which there were possibilities of obtaining a large number of minor products at present, perhaps, unknown and therefore unwanted in the world. Nevertheless, the Gas Industry could, if it made up its mind, create a demand for these products through the medium of research and the acquisition of more knowledge.

Importance of Research.

Sir CHARLES BOYS, F.R.S., proposing "The Institution of Gas Engineers," said he was amazed at the amount of research work that was being done by the Institution and in the Industry generally, and he must associate himself with what the Earl of Dudley and Sir Frank Smith had said as to the enormous importance of research. On this point Sir Charles referred to a visit he paid to America nine years ago when he had seen the enormous research station of the Edison Bell Company, and more recently when he had visited the Research Laboratories of the General Electric Company at Wembley, and suggested that developments along the same lines in the Gas Industry would well repay themselves if only one out of a large number of researches turned up trumps. The President, in proposing the Toast of "The Guests," had remarked that sometimes, by an accident, an important result was happened upon; but he emphasized the point that it was only by fundamental research, with no practical object immediately in view that great discoveries were made.

Mr. R. ROBERTSON (Vice-President), responding to the Toast, said they were deeply sensible of the compliment Sir Charles Vernon Boys had paid them in coming to the luncheon and proposing this Toast, and they appreciated very highly the discriminating and eulogistic commentary he had made upon the Gas Industry. The Industry suffered from various handicaps which militated against a widespread recognition of its merits. It was not sufficiently old to command veneration, and it was not sufficiently young to excite wonder and a belief in miracles. It did its job so quietly and efficiently that it was taken for granted. Its most conspicuous feature—the gasholder—had become a matter for jest; but their electricity friends would give anything for an equally effective means of storing energy. Then again, in an age when most key industries had joined the ranks of distinguished invalids and the political doctors had been called in—or had forced an entrance—it continued to enjoy good health, balance its budget, and minded its own business with a fair amount of success. Normality, however, did not provide good "copy" for the popular Press, and the public was not interested in healthy, solvent respectability, with the result that an intelligent appreciation of the Industry's activities was seldom met with outside the Industry, and those responsible for legislation affecting industry and public service often acted as if it did not exist at all. Notwithstanding its handicaps, however, and perhaps to some extent because of them, the Gas Industry continued to prosper, and The Institution of Gas Engineers was proud of the contribution which its members had made to that end. It was not too much to claim that the future success of the Industry was to a very great extent in their hands. During the past 25 years there had been a revolution in the technique of gas management. He need only refer to the special organizations created for dealing with commercial, legislative, and publicity problems. The technical problem remained the special province of the Institution, and the character of its membership to-day reflected the change which had been taking place. Production, distribution, and utilization had now become separate professions. The engineer, the chemist, and the physicist had emerged, and ample scope was found for each in the team work which had become an essential feature of the Industry, not only in the design and control of the means of production and utilization but, what was equally important, in promoting and conducting research, the object of which was to improve the quality and range of the products of the Industry and provide better and cheaper service to the public. The November Research Meeting provided the opportunity of giving an account of their stewardship in this latter direction, and it was hoped that the many friends, both inside and outside the Industry, who had helped them, were satisfied with the progress being made.

Mr. HENRY WOODALL, proposing the final Toast of "The Chairman," said he had known Mr. Smith fairly intimately for 17 years, and it had been one of the pleasures of his life to see the manner in which Mr. Smith had earned the respect of his brother engineers. Indeed, he had won the respect of everybody with whom he had come into contact. It had been said that it was better to travel hopefully than to arrive; but Mr. Smith had both travelled hopefully and had arrived, for he had secured the blue riband of his profession—namely, the Presidency of The Institution of Gas Engineers, the highest honour that his brother engineers could confer upon him. They all admired their President, they all liked him, and delighted to do him honour.

The CHAIRMAN briefly acknowledged the Toast.

Extract from "Gas Journal," Nov. 3, 1937

FLEX PLUG AND SOCKET CONNECTORS

The increased popularity of portable gas appliances is reflected in the sales of flex plug and socket connectors, of which over a million are now in use. The flex plug and socket connector was developed to supersede the old push-on connector, and to serve a parallel purpose to the electric plug.

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(3) The plug can now, if desired, be left assembled in the socket in the off position, which will prevent the possibility of damage to engagement lugs if left lying on the floor when disconnected.

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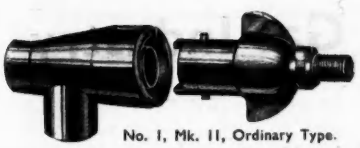

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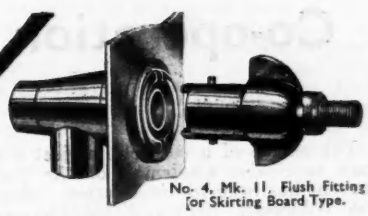

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The Society of British Gas Industries

R. J. ROGERS, Chairman of the Council.

The Autumn General Meeting of the Society of British Gas Industries was held at the May Fair Hotel, London, W. 1, on Thursday, Nov. 4—the President, Sir HAROLD HARTLEY, in the chair.

The opening business of the meeting was concerned with a resolution for the formation of a new Coke Oven Section—to be known as Section XVIII.

Mr. F. B. RICHARDS, in putting the proposition, said that there had been a tendency in recent times for the boundaries between the gas and coking industries—at one time quite clear-cut—to become less definite, and the many points which these two industries had in common tended to bring them closer together. What was true of the operating side of the Industry was true also of the contracting side. Some twelve months ago the need was felt by certain members of the Society of British Gas Industries who were engaged in the building of coke ovens for a common platform whereon they could meet their confreres similarly engaged who were not members of the Society.

In these circumstances, said Mr. Richards, the Council of the Society was approached to know whether in the first place they would welcome an application for membership from the coke oven builders who were up to that time outside the Society, and whether, in the event of their joining, the Council would approve the formation of a Coke Oven Builders' Section. The Council's reply, in which they were influenced to no small extent by the considerations mentioned, was in the affirmative to both propositions. Mr. Richards was pleased to be able to say that the Society could now claim 100% membership of the firms established in this country as builders of coke ovens. He therefore had much pleasure in moving the resolution that this meeting approve the formation of a new Section—which would be No. XVIII—to accommodate all those engaged in the building of coke ovens.

Mr. R. J. ROGERS (Chairman of the Council), in seconding the motion, said it was necessary to bring the matter before the meeting that day, though ratification and the alteration in the rules involved would take place at the Annual General Meeting in May next.

The resolution was unanimously agreed.

Thereafter Mr. ROGERS delivered his Chairman's Address.

THE CHAIRMAN'S ADDRESS

Co-operation and Service in the Gas Industry

By R. J. ROGERS

The choice of a suitable subject for the Address which each successive Chairman of the Society is expected to present has been to me a rather difficult task. A study of the Addresses delivered by Chairmen of the Society during the past thirty years indicates that almost every phase of the business activity of our members has been dealt with, and the Addresses themselves bear adequate testimony to the valuable work the Society and its members have carried out in the service of the Gas Industry during this lengthy period.

Constitution and Activities of the Society.

Many of my predecessors in this Office have taken advantage of the Autumn Meeting to refer in some detail to the activities of our Society. Few opportunities present themselves during the year for collective gatherings of our members, and I may therefore be excused if I take this opportunity of reminding not only our own members, but others in the Gas Industry, what we are really doing to-day and the share we are taking in promoting the interest and well-being of the Gas Industry. Notwithstanding the fact that this Society has been in existence for over thirty years, there are still a number of those engaged in the Industry, and perhaps particularly the younger members, who have little knowledge of the activities of the Society or realize the extent to which we are associated in the ever increasing problems which confront the Industry.

It is significant that the Society was inaugurated at what may be considered the first co-operative publicity and exhibition movement in the Industry, namely, the Earl's Court Gas Exhibition in 1905. Many of the prime movers in the enterprise have, alas! passed from us, a notable loss during the past year being Mr. Charles Clare, who was responsible for convening the inaugural meeting and who was appointed the first Chairman of the Society. It is not necessary for me to quote in this Address the official objects of the Society, which are to be found in our Rules. Suffice it to say that the keynote underlying many of them is co-operation and the promotion of reciprocal good feeling and mutual confidence between contractors, manufacturers, and the gas supply authorities and their officials. A study of the progress of the Society over the past thirty years clearly indicates that the spirit of co-operation which animated the founders of the movement has grown in increasing measure from year to year, and is still an outstanding characteristic of our relationship with other branches of the Gas Industry.

The extent to which our members are associated with the Gas Industry may be realized from the wide range of interests represented by the various sections of the Society. These include makers of retort settings, retort mountings, condensers, and purifying plant; conveying plant and labour saving machinery; coke oven plant; makers of gasholders, meters, gas stoves, gas lighting equipment, gasfittings and burners, and general supplies; makers of industrial gas equipment, fireclay goods, exhausters, chemical and residual plants, and water gas plants; contractors of coal for gas manufacture; makers of tubes and pipes, water heaters and scientific instruments—in short, the whole range of activity which the Society was designed to cover. There is no phase of manufacturing or contracting activity connected with the Gas Industry which is not associated with the work of the Society. For the purpose of administration the members associated with the interests outlined above

are divided into sections, eighteen sections being in existence at the present time. The members of each of these sections appoint their own Chairman; these eighteen chairmen of sections with the officers and elective members constitute the Council of the Society.

I have purposely referred to the various sections of our Society in order that those in the Industry who are unacquainted with the functioning of the Society may better realize the extent to which the activities of our members enter into the everyday progress of the Industry.

Co-ordination.

The progress of co-ordinating the various interests and workers in the Industry has made remarkable strides during the past twenty-five years, and I think we shall all be agreed that beneficial results have followed each "linking-up" of associated interests. In reviewing this gradual co-ordination of interests in the Industry, it is noteworthy to record that possibly the first important fusion took place in 1902 when the Incorporated Gas Institute and the Incorporated Institution of Gas Engineers merged their interests in The Institution of Gas Engineers, which subsequently received a Royal Charter.

From time to time since 1861 various District Gas Associations have been formed which, including Associations in Scotland, Ireland, and Wales, now cover the whole area of the United Kingdom and Ireland. The Gas Companies' Protection Association was formed in 1898. Our own Society was, as I have already mentioned, inaugurated in 1905, and other important Associations followed in the formation of the British Commercial Gas Association in 1911 and the National Gas Council in 1916. All these organizations have carried out admirable work in their respective spheres, and there can be no doubt that the present sound position of the Industry is due in no small measure to the influence exerted and the energy with which each organization has accomplished its allotted task.

The year 1934 witnessed the welding together of the five main organizations: The I.G.E., S.B.G.I., B.C.G.A., N.G.C., G.C.P.A. in the British Gas Federation. This co-ordination represented a very notable advance, and already in the short space of the three years of its existence striking advantages have been witnessed of the value of co-operative action in many matters affecting the interests of the Industry as a whole.

The Women's Gas Council, started in June, 1935, now has 36 branches, with a membership of over 6,000, and three affiliated organizations. It provides housewives with opportunities of studying the latest developments in dietetic work and hygiene, developing a wide understanding of the service of gas in the home and in connection with housing, smoke abatement, child welfare, and the health of the nation. The Council is working in close conjunction with many other national women's organizations, so that its members have a voice in much of the important work which is being done by such organizations to-day.

South Kensington Science Museum.

I should like at this stage to mention a matter of great topical interest. Hitherto the Gas Industry almost alone among the great industries possessing real technical interest has been virtually unrepresented at the South Kensington Science Museum, while other branches of engineering, including the electricity supply industry, have elaborate and extensive displays. This anomalous position was brought to the notice of the British Gas Federation. It was studied by a committee of that body, and now as an Industry united through the Federation we are setting out to raise a fund of not less than £20,000 to stage a permanent large-scale Gas Industry Exhibit. The Society has been associated throughout with all the discussions which have taken place, and will be closely associated in the task of planning and organizing the whole exhibit. In short, the consideration which is always before the S.B.G.I. Council, that where we are asked to make a financial contribution we in turn should seek for representation, has in this case been fully met through membership of the Federation. In these circumstances, and in view of both the practical and prestige value to the Industry of being adequately represented in the national repository for the display of the world's great scientific inventions and industrial processes, I commend this appeal to the very generous consideration of all our members.

Co-operation.

I have always been a keen advocate of linking up, to what may be termed the major or senior Associations, those in junior positions in the Industry. In the course of my Presidential Address to the Midland Junior Gas Association twenty-six years ago I said "the affiliation or representation of the whole of the workers in the Gas Industry to a central organization is, in my opinion, a desideratum; the cohesion of all ranks is desired, from the gasfitter's boy and the junior clerk upwards, in order that the labours of all may be brought to a successful issue."

During the past 15 years there have been formed in conjunction with the B.C.G.A. various Gas Salesmen's Circles, and I am proud to have been associated with the initiation of that movement and to have held the office of first Chairman of the Midlands District Circle. The importance of the Sales Section of our Industry is being more generally appreciated than it was some years ago, and the value of the affiliation of gas salesmen through their respective circles to the senior publicity sales organization, the B.C.G.A., receives greater appreciation year by year. Salesmanship combined with service are the most potent factors affecting the Industry at the present time, and on the degree to which they are advanced will depend in large measure the future prosperity of the Industry.

The manual workers through their various trade organizations may be said to be affiliated to the main membership structure of the Industry, as their leaders by means of the National Joint Industrial Council are working in amicable relationship with the employers in all branches of the Industry.

The Associations I have mentioned cover a large proportion of the engineering and administrative branches of the Industry, including the sales organizations, and compared with many other large industries the Gas Industry may well feel proud of the high standard of co-operation it has achieved. Notwithstanding this high degree of co-ordination of interests, we cannot say finality has been reached, as there still remain many valuable technical workers in the Industry who are not linked by direct membership to the senior organizations. I refer particularly to those engaged in the technical, chemical, and research laboratories of manufacturers and of gas undertakings. These workers are contributing in no small measure to the progress of the Industry, and I can only express the hope that some steps will be taken in the near future which will enable them to be appropriately associated in a manner commensurate with their importance and value to the Industry.

The Committee Question.

One often hears it said that there are too many committees and too many meetings to attend, and also that all too frequently the same individuals are appointed to the Committees. There can be no denying the fact that to many individuals the demands of council or committee work are extremely heavy. If, however, the management of the Industry is to be carried on effectively it is virtually impossible to eliminate the various committees, but I have always held the opinion that more could be done in spreading some of the sub-committee work over a larger number of members in an organization and thus release the burden from many already busy men. A recent noteworthy example in this direction has been the appointment of standing sub-committees by the British Commercial Gas Association. These committees deal with finance, publicity, and general services, and experts in the particular branches have been appointed to these committees, which function each with its own chairman. This re-arrangement should result in greater efficiency in dealing with the important matters which come under the ægis of the British Commercial Gas Association.

Chart.

Having briefly dealt with the general organization of the Industry, let us consider the degree to which this Society in particular is able to collaborate with the other national bodies. The chart shows the relationship of the various organizations and the committees through which the members of the Society contribute to the work of the Industry. A study of this chart discloses the wide ramification of interests covered by the main national bodies, and while for the purpose of clarity I have not included every sub-sectional organization in the Industry, sufficient has been indicated on the chart to emphasize the paramount need for the closest co-operation by all concerned if the utmost value is ultimately to be obtained from the efforts of the individual organizations and their respective committees.

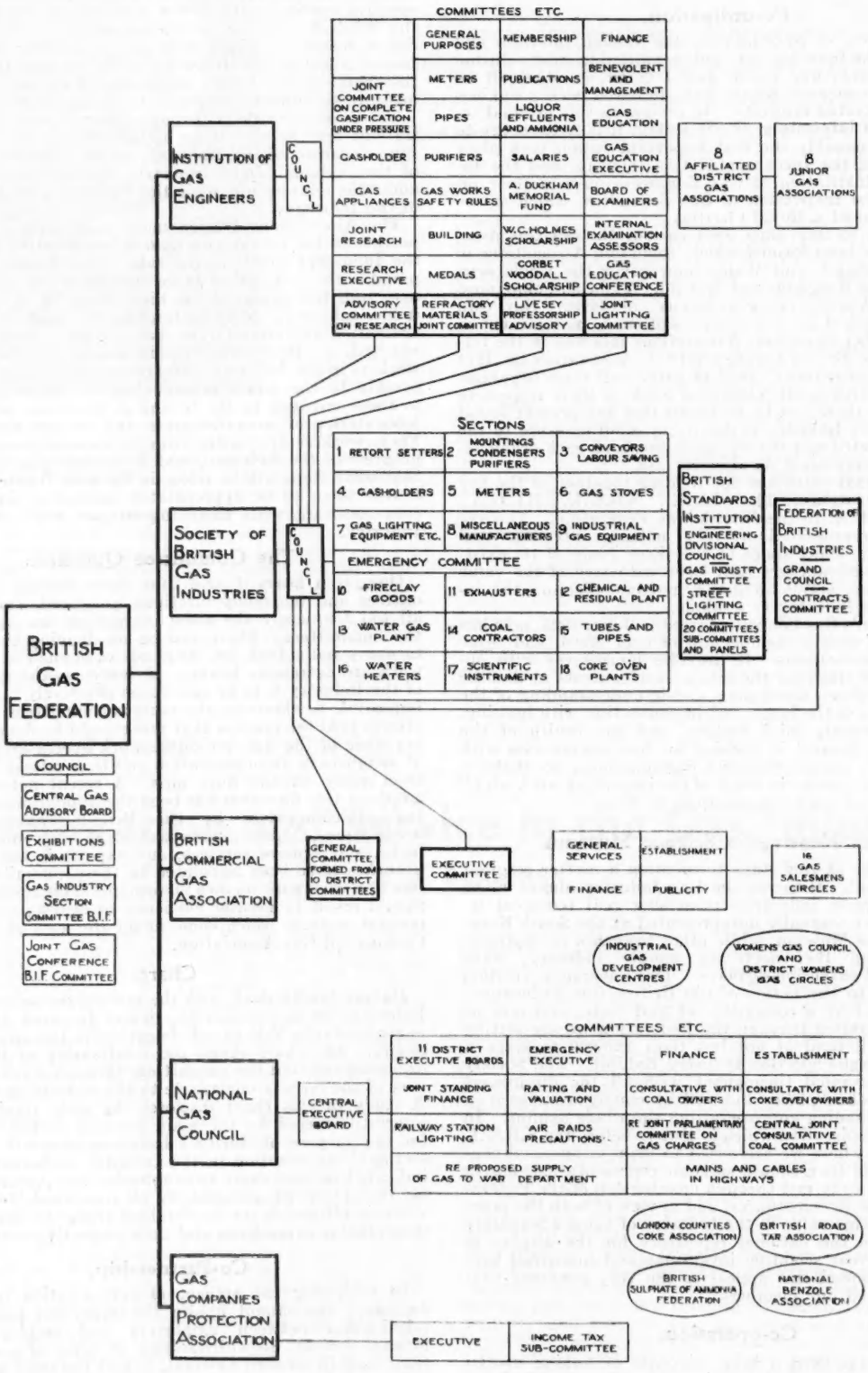
Co-Partnership.

In reviewing the subject of collaboration in the Gas Industry, one cannot ignore the important factor of the relationship between employers and employees. The human element, notwithstanding all types of machine systems used in modern business, is still the most potent and the most important factor in business. While we are striving to obtain the co-operation desirable in industry, we must take steps to ensure that individual initiative and responsibility are encouraged to the fullest possible extent, for on this depends the very lifeblood of our Industry. The name of the late Sir George Livesey, a Past-President of this Society, will always be remembered as that of the

pioneer of co-partnership and profit-sharing. It is fit and proper, therefore, that the Gas Industry should take the lead in the number of schemes and employees affected. The scope and development of the co-partnership system within the Industry are well known. Year by year the sharers in these schemes do, I feel, appreciate increasingly the advantages of the system, though it is impossible to state in terms of real value the benefit which the Gas Industry has derived from sharing profits with the workers.

To give one's employees a financial interest in the firm, above and beyond his weekly wage or salary, ensures a greater interest in the progress of the business and provides the best incentive to enthusiastic and devoted service. That the Gas Industry is appreciative of the value of encouraging the employees is shown by the fact that of 266 co-partnership and profit-sharing schemes in operation during 1936, sixty schemes applied to the Gas Industry, affecting some 50,000 employees compared with 220,500 for

Chart of National Organizations of the Gas Industry



the whole of industry. (These figures do not include Co-operative Societies.) Moreover, while there has been a gradual decline in the number of schemes in operation since 1929, this decline has not been noticeable in the Gas Industry.

Schemes in Various Industries.

The following table issued by the Ministry of Labour shows the number of employees entitled to participate in the schemes in various industries at the end of 1936:

Industry.	Number of Schemes.	Total Number of Employees.	Employees Entitled to Participate (Approx.).
Agriculture	3	200	100
Brick, chemicals, &c.	16	21,500	16,300
Metal, engineering, &c.	33	88,400	45,900
Textile	19	25,600	15,600
Food and drink	27	41,300	24,500
Paper, printing, &c.	25	15,700	7,300
Gas, water, and electricity supply	68*	65,300	54,100
Merchants, warehousemen, and retail traders	35	49,900	13,200
Banking, insurance, and finance	12	40,000	28,900
Other businesses	28	23,300	14,600
Total	266	371,200	220,500

* Out of this number 60 schemes apply to gas undertakings; a considerable proportion of the principal company-owned undertakings have introduced schemes, a number having been in operation for more than twenty-five years.

The following table gives comparative figures for the years 1927-36 of bonuses paid under schemes for which details are available:

Year.	Number of Schemes.	Average Amount a Head.	Addition to Earnings.
		£ s. d.	%
1927	380	8 11 11	4·0
1928	414	8 17 9	4·4
1929	419	9 9 11	4·8
1930	427	10 2 11	5·7
1931	414	10 6 7	5·4
1932	390	9 10 5	5·2
1933	382	10 18 8	5·6
1934	367	10 12 3	5·7
1935	352	10 14 6	5·8
1936	363	11 6 2	6·1

The addition to earnings as shown in the above table, while not being in any way spectacular, represents a very welcome contribution to the worker's income; £11 6s. 2d. means 4s. 4d. per working week, and to a household of small earning capacity this is sufficiently noticeable to raise the standard of living. In reviewing these figures one may well consider how many strikes engendering bitterness have been called in many industries, and prolonged with loss to both employee and employer, for the sake of much smaller material advantages than are represented by the above additions to earnings under a co-partnership scheme.

The Gas Industry as a whole may rightly claim that, for many years past, it has worked in close harmony with the responsible leaders of the labour organizations, and has dealt in an equitable manner with all its employees. The members of this Society as large employers of labour are—by the promotion of welfare schemes, by their sympathetic and just handling of various labour problems—contributing in their respective businesses in no small measure to the attainment of that spirit of cordial co-operation between all workers in the Industry without which we cannot expect to achieve maximum success.

Pension Schemes.

Another factor contributing to better relations between employer and employee, which has been steadily growing in recent years, is that of superannuation and various forms of pension schemes. Apart from the national superannuation schemes applicable to national and local government officials and workpeople, there are a number of schemes in operation associated with industrial organization. In our own Industry many gas companies and many members of this Society have instituted pension schemes—some on a contributory basis and others of a non-contributory character. The National organizations of the Gas Industry also have pension schemes for their staffs. Everyone will, I feel sure, agree that the existence of such schemes is a vital factor tending to promote better relationships between employer and employee and is calculated to lead to proficiency in business. Any scheme of superannuation or pension which effectively removes doubt and anxiety as to financial income in old age cannot help but add to the happiness of the worker and contribute to the general improvement in his or her capacity to give better service to the employer.

The Need for a National Pensions Scheme.

Existing schemes vary considerably in the pension benefits they confer upon the worker, and while I should deprecate any measure which would in any way reduce the value of the many voluntary schemes which employers have instituted, I do consider the time is rapidly approaching when some national scheme of pensions should be instituted on a contributory basis to apply to the whole of the workers in the country. Something more than the present Old Age Pension Scheme is wanted, which should include every worker in industry, irrespective of his rate of wage or salary. If such a scheme were made compulsory, its cost would be spread over every trade and industry, and no unfair charge for pensions would be borne by competing interests. Workers in many trades would be enabled to retire at a reasonable age on a sufficient pension to enjoy a little leisure at the end of their working life instead of, as obtains to-day in many establishments, working until they reach an advanced age when their efficiency is greatly impaired.

I am well aware of the many difficulties to be overcome in the consideration of such a national pension scheme; but many of the original objections to national superannuation schemes for Government and Municipal workers have already been surmounted, and, as is well known, such schemes are in active operation, conferring benefits on scores of thousands of officials and workers. Many pension schemes, as I have stated, have been instituted by employers in the Gas Industry, and I can only express the hope that such employers may use their influence, whenever possible, to ensure the advancement of a system of pensions, the general adoption of which should prove beneficial and add still further to the goodwill existing, and to the closer cohesion of all ranks in the Industry.

Training for Leisure.

Closely allied to the question of pensions is that of the training or education of the worker in the manner in which he can best utilize his leisure time. This is a phase of welfare work which I should like to see developed by all employers of labour. Insufficient attention is, in my opinion, devoted to the problem. Time will not permit me to dwell at length on this interesting subject, but I trust that the members of this Society will give consideration to the promotion of talks, and in other directions demonstrate to the workers, methods and practices of hobbies and other means calculated to maintain the physical and mental wellbeing of the worker during his leisure time.

The Future.

In any industry or individual business it must be recognized that before any guarantee of progress can be assured the utmost possible co-operation and unification of effort must be achieved. I have already indicated that as an industry we have achieved a remarkable measure of co-operation between all the interests involved, and in this respect we have established a firm foundation on which our future activities may be based. As members of a society of contractors and manufacturers, to whichever branch of the Gas Industry we devote our energies, we must as business men ask ourselves—What are the potentialities for future business and how can we achieve the maximum of success? As our progress is inseparably bound up with the general progress of the Gas Industry, it is essential that we should all obtain a clear appreciation of the fundamental basis on which the future of gas depends.

Service to the Consumer.

There is, I think, general agreement that the future of gas depends upon service to the consumer. On this subject I would direct your attention to the excellent Paper on "The Future of Gas Appliance Design" submitted by C. A. Masterman, M.A., M.I.Mech.E., F.I.C., Chief Technical Officer of the Watson House Laboratories of the Gas Light and Coke Company, at the Annual Meeting in June last of The Institution of Gas Engineers. In speaking of the future of gas utilization, Mr. Masterman said: "Expansion in the use of gas comparable with the opportunities which lie ahead can be realized only by wholehearted co-operation between the gas undertakings and the appliance manufacturers. The future will show no demand from the community for gas as a commodity, but an increasing demand for the *service* which gas can give. This change in public mind in viewing gas no longer as a commodity, but as a service, is to be welcomed, *but its profound effects have yet to be appreciated by the Gas Industry as a whole.*" I have purposely italicized this last

sentence quoted from Mr. Masterman's Paper, as I consider the statement cannot be too strongly emphasized. "Service to the Consumer" is a slogan which has been very widely adopted, but in many instances, I fear, without a full realization of all it demands.

The following extract from the Presidential Address of Councillor W. P. Jackson delivered at the recent B.C.G.A. Conference at Manchester is worthy of note: "The success of gas undertakings should not be measured by the amount of profit made, but by the service rendered to the community, for increased sales are far more important than increased profits. Real service gives satisfaction, and satisfaction automatically procures increased sales, but the service must be in the best interests of the consumer. Service does not mean merely persuasive salesmanship. It must consist of such expert advice and assistance that it will enable consumers to obtain the maximum value from the gas for the particular purpose for which it is employed, and this means that industrial processes must be carefully studied. Gas is indispensable to industry, and this strong position must be maintained by further research and investigation."

Gas Quality.

Mr. Masterman in the Paper to which I have already referred said "The first criterion in any service must be reliability," and to ensure this reliability he advocates the standardization of gas quality, of calorific value, specific gravity, and combustion characteristics, and he also stresses the necessity of reducing the sulphur content of gas, anticipating that in future a sulphur content not exceeding 10 grains per 100 cu.ft. will be obtained. With these points I am fully in agreement. Within the last few years it has been brought more forcibly to the notice of designers that an appliance may behave very differently when tested under different gases. Of recent years there has been a general tightening up of standards both of combustion and performance, and in meeting these standards the effects of various gas properties have had to be investigated. It has been customary to take into account in the design of appliances the calorific value and specific gravity, where known, of the gas supplied by any particular company, but means of adjustment have always been provided so that the company's fitters could adjust the appliance actually on the premises to ensure satisfaction. This final adjustment, however, invariably depends upon the judgment of the fitter. Efforts are now being made to eliminate this personal factor.

Considerable prominence has been given of late to the variation in burning characteristics which may take place in gas of the same calorific value and specific gravity. Two gases, having identical calorific values and similar specific gravities may yet give different flame characteristics, and through work that has been carried out on the Continent and in England for some years now, it is possible to obtain an arbitrary burning standard whereby the characteristics of one town's gas may be reproduced in another town for test purposes. The testing of modern appliances therefore includes performance with gases of different calorific value, specific gravity, and burning characteristics.

Public Lighting by Gas.

It is deplorable that in the minds of many persons in the Industry a spirit of pessimism and apathy exists in regard to the future of public lighting by gas. When we realize that gas provides over two-thirds of the street lighting in this country and that in many undertakings it represents from 5 to 7% of the total output of gas, it will, I think, be generally agreed that it is a load which is well worth retaining. If this business is lost, it is obvious that very great efforts accompanied by a large expenditure of capital will be necessary to replace the gas thus consumed, and to do so new loads will have to be sought. Whether this may be in the direction of water heating or by any other means, it is, in my opinion, inevitable that a considerable amount of capital must be spent by the gas undertakings in providing apparatus which in all probability would have to be offered on hire terms. By the expenditure of a comparatively small sum of money substantial and striking improvements in public lighting could be effected, which would provide a scheme of gas illumination that would meet the approval of those responsible for the lighting of streets, and convince the public at large that gas can adequately fulfil all street lighting requirements.

I am well aware of the difficulties which administrators of gas undertakings have to face in their endeavour to retain the gas street lighting load. Committees of local authorities responsible for the lighting of highways are in many instances too ready to accept a competitive system of electric street lighting as being more up-to-date than gas without impartial judgment of the intrinsic merits of the two systems of illumination. This is another department of Gas Industry business where we only ask for "a fair field and no favour." The public and the authorities responsible for public lighting must be made aware of the possibilities of gas as a street lighting medium when the latest equipment is employed, and when similar factors in mounting height and the like are accorded to gas as to competing illuminants. I believe that the public lighting load can, in a large measure, be retained, provided the Industry is prepared vigorously to apply its energies in promoting improved systems of gas lighting. Progress in public lighting by gas, or even the retention of existing business, will not be effective unless all the gas interests involved are united in a co-ordinated policy, and make a whole-hearted effort to improve the standard of public lighting by gas.

An Instance of Co-Operative Effort.

During the past year a notable advance has been made. An "Ad Hoc" Committee, comprising members of this Society, of the I.G.E., and of the B.C.G.A., was set up to review the whole question of public lighting by gas, and to make recommendations covering not only the technical and commercial aspects, but also the broad policy of the Industry in regard to the general problem of public lighting. The S.B.G.I., I.G.E., and B.C.G.A. had all been deeply concerned in public lighting, and, severally and jointly, had done useful work, but there was a great deal of overlapping. It was the chief function of the "Ad Hoc" Committee to ensure that the efforts of the three organizations concerned dovetailed rather than overlapped, and the findings of the Committee are worthy of the closest attention as an instance of the co-operation which is possible between all sections of the Gas Industry to solve a given problem.

It was appreciated that the experts appointed to serve on the Joint Lighting Committee were competent to deal with any technical questions arising from a consideration of the subject, the examination of suggestions for improvement in lighting units, investigations and the examination of technical reports, such as the Ministry of Transport Report and the British Standard Specifications. Section VII. of this Society was involved in both the technical and commercial aspects, in the formulation of street lighting schemes, the surveying of districts, the preparation of comparative costs, and the provision of experts to advise gas engineers on street lighting schemes. Finally, the B.C.G.A. was capable of dealing with propaganda, publicity in trade and other journals, refutation of unwarranted competitive claims, and replies to competitive publicity, together with the preparation of handbooks, lectures, &c. When once the most useful respective functions of the three bodies had been defined and agreement had been reached on the methods of co-operation between them, advances were bound to follow. Indeed, the results of the efforts of the "Ad Hoc" Committee have already borne fruit, in that there exists to-day a greater degree of co-operation of effort than ever before.

The A.P.L.E. Conference.

At the Folkestone Conference of the Association of Public Lighting Engineers held in September the up-to-date gas street lighting installations demonstrated beyond any doubt that street lighting problems could be adequately and economically dealt with by the older and tried illuminant. Every gas lamp manufacturer had a new and better lamp to exhibit, the details of which have been fully described in the Technical Press. While referring to the Folkestone Conference a tribute must be paid to the President, Mr. C. T. Winstone, Public Lighting Superintendent to the Gas Light and Coke Company, whose genial optimism and unbounding enthusiasm was in large measure responsible for the success of the meeting. Manufacturers of gas street lighting equipment are greatly indebted to Mr. Winstone for his efforts in making possible the demonstrations of up-to-date gas street lighting units which were on view.

That there is need for improvement in the public lighting of our streets no one will deny, and I am satisfied that the Gas Industry is capable of rendering still greater service to the community by providing a higher degree of suitable illumination on the highway.

The Need for Standardization and Pooling of Research.

Large Laboratories maintained by the appliance manufacturers are essential to cope with the immense amount of detailed testing required to produce appliances suitable for use under all the varying conditions of service, and, while close co-operation between gas undertakings and the appliance manufacturers does greatly help in the production of efficient designs, it in no way reduces the amount of independent work to be carried out by the appliance manufacturers, but may even increase it. It is not many

years since the Gas Industry depended almost entirely on the manufacturers of appliances for research, initiation, and development work in connection with gas consuming appliances, and although in recent times the situation in this regard has changed, we are all, I am sure, not unmindful of the debt the Industry owes to those manufacturers who in the past have pioneered many epoch-making developments in appliances for the effective consumption of gas. The collaboration of the research officers of appliance manufacturers with those engaged at Watson House, and others in many provincial gas undertakings, is indicative of the spirit of co-operation which exists to-day between manufacturers of appliances and the supply undertakings of the country. Those of us who have experienced the value of such co-operation realize how greatly the Industry has benefited. Such establishments as Watson House and other research organizations in this country are in a position to obtain first-hand information of the performance of different appliances in actual use on the district, and this information is of the utmost value when it is communicated to those who are responsible for designing and producing such appliances.

Since the cost of all research and development work must ultimately be borne by the selling price of the appliance, it will be seen that the standardization of appliances, by helping to reduce the manufacturing costs, will make it possible to supply a better article to the consumer. Few gas undertakings in the country realize how great is the increase in cost incurred by a slight alteration in a standard specification. Whereas an appliance manufacturer desires to produce one model with the object of supplying the best possible article at the least possible cost, different gas undertakings and laboratories frequently demand variation both in design and performance in order to comply with their own specific tests. Any standard appliance must be sufficiently adaptable to deal with the known variations in gas quality which exist in the country. It becomes much more difficult, however, to produce a standardized appliance that will not only function satisfactorily from a technical point of view under all circumstances, but which will also satisfy all local idiosyncrasies.

It is to the advantage of the gas undertakings to order to standard specifications wherever possible, since the makers can hold large stocks and therefore give immediate deliveries, while the greater ease of production will lead to lower prices and higher quality. It must not be thought, however, that this plea for the acceptance of standard models is an argument in favour of rigid standardization in appliances generally; such standardization would mean that the different manufacturers would be limited in their designs, whereas, in my opinion, the introduction of standard appliances by the individual manufacturers permits a healthy rivalry in design. At the same time the existing state of affairs, where each individual gas undertaking frequently calls for its own individual specification on the otherwise standard article should be modified if a real degree of standardization is to be attained.

The British Standards Institution.

The British Standards Institution, in conjunction with the Gas Industry, is working on a series of standard tests to be applied to gas appliances; the first and most important of the specifications deals with combustion standards and has already been issued (Combustion Testing of Domestic Gas Appliances No. 717/1936). This specification defines clearly the combustion standard required for various appliances, and standardizes also the method by which the tests are to be carried out. Further standard tests relating to gas cooker performance will be issued in the future, and it is important that the Industry should realize the purpose of these standards. The Standard Specifications are intended to serve as a guide both to manufacturer and buyer, so that new appliances may at least conform to the existing standards of performance. It is important to realize that these standards serve to indicate (1) that the appliance will be safe to use under ordinary service conditions, and (2) its technical performance will not fall below the average existing performance of its own class.

It is my opinion that this is all that should be attempted in specifications of this type; in other countries, notably in America, not merely have performance specifications been issued, but also structural specifications, and in more than one instance—notably the oven performance specifications of the A.G.A.—these have been found to hinder progress, as they have been so worded that the manufacturer was limited not only to minimum performance, but also to maximum performance, and it should be realized that while a sound specification proves a safeguard against shoddy design and workmanship, it may also, if interpreted too rigidly, prove a serious bar to progress. The British Specifications have been drafted by a panel consisting of representatives from the large gas undertakings as buyers, and also from the gas appliance manufacturers. Such a representative panel is unlikely to recommend specifications, on the one hand, that are too low in standard to be of value, or, on the other hand, too rigid to permit of further development.

Central Testing Laboratory.

It has often been suggested that the Industry should subscribe towards a central laboratory at which independent research work could be carried out, appliances tested, and from which standards could be issued. Twenty-six years ago in my Presidential Address to the Midland Junior Gas Association in advocating the need for testing laboratories for gas appliances, I suggested that consideration might be given to the formation of a central testing laboratory for the Industry. Since that time, however, remarkable developments have been made in the establishment of testing laboratories by many of the large gas undertakings, and the principal gas appliance manufacturers have extended their activities in research work. A central laboratory for the testing of gas appliances therefore, in my opinion, is not necessary at the present time. The institution of such central laboratories may be of great value in large and scattered countries, even where large concerns still retain their own laboratories for private work. In our own case, however, it is doubtful whether an independent central laboratory would prove as valuable, in furthering the interests of the Industry, as the existing system whereby the technical and research departments of the manufacturers and of the large gas undertakings meet together to discuss the problems associated with the setting up of standards which are to deal with the design and performance of appliances.

Pooling of Knowledge.

This pooling of knowledge in collective research is undoubtedly good for the whole of the Gas Industry and for the vast community which it serves. In this connection it is interesting to record the observations of Lord Dudley, the President of the British Gas Federation, when speaking recently at the Annual Meeting of the Institute of Vitreous Enamellers over which our esteemed President, Sir Harold Hartley, presided. Lord Dudley said: "We all agree there is no question of the importance and the necessity, in these modern days, of trade institutes and trade associations. The days of the lone industrialist and the lone alchemist—the lone alchemist in his solitary chemist's shop or laboratory, closely guarding his processes and secrets and terrified lest anyone else should discover them—are long past and done with. It has been discovered in these modern days that pooled knowledge pays best in the long run. We work under such high pressure to-day that there is not time to work a lone hand. It is a serious enough difficulty to keep up to date with the pooled knowledge that is disseminated to us by highly-organized trade institutes of this sort. There is no room any longer for the jealous individual industrialist that we remember in our young days. Besides that, science marches on so rapidly that it is only by pooled knowledge, research, and experience that we can keep abreast of scientific advance at home and abroad, and so maintain our place in the export markets of the world."

Conclusion.

There is every reason for all of us to regard the future of the Gas Industry with optimism. It is advancing rapidly in its service to the community. It is faced with many interesting problems at the present time which are being investigated with vigour by many of the leaders in the Industry, and this should prove an incentive to the younger men in our ranks to emulate them.

The consideration of the development of new loads such as water heating, central heating by gas, and the use of gas for industrial purposes; rate structure, marketing research and planned selling; salesmanship in all its aspects; these are only a few of the subjects which will provide ample scope in the near future for the utilization of the best brains in the Industry.

The primary concern of the members of the Society of British Gas Industries must always be the production of improved plant and apparatus for the manufacture and utilization of gas, the design and production of more efficient and attractive appliances, and the training of technical experts for research.

I have endeavoured in my Address to indicate that the Society has in the past taken its full share in the advancement of the Industry—by encouraging co-operation, by the co-ordination of interests, and by collaboration with all sections of the Industry. I am convinced that it is only by such unification that we shall be able to create for ourselves an unassailable position in the world of competitive endeavour.

Ours is a goodly heritage—let us prove worthy of it.

Vote of Thanks.

Col. O. B. F. PLANCK proposed a hearty vote of thanks to Mr. Rogers for his most interesting Address, the nature of which, he said, was peculiarly appropriate to the occasion. Although the Autumn Meeting of their Society was a purely domestic one, nevertheless he prophesied that Mr. Rogers' Address would be of much wider interest to, and would be welcomed by, all other sections of the Gas Industry. There were many people closely associated with the Industry, including members of their Society and also those connected with technicalities and sales on the supply side who had hitherto not been very clear as to just what were the objects and the *raison d'être* of the S.B.G.I. The chart included in the Address was, he considered, a valuable exposition of the responsibilities of the five principal organizations which were grouped together in the British Gas Federation. He submitted that this chart, taken in conjunction with Mr. Rogers' Address, was worthy of detailed study, the result of which would be to clarify the organization and ramifications of the Industry. It made one appreciate the very great wisdom and foresight shown by Sir David Milne-Watson and the other gentlemen who were concerned in the formation three years ago of the B.G.F., because the chart immediately revealed the need for co-ordination to-day.

The B.G.F. had, since its inception, proved of very great value to all sections of the Industry, and Col. Planck felt safe in saying that in a few years its usefulness would become increasingly appreciated. Mr. Rogers' Address showed just how their Society fitted in with the other bodies in the Industry, and indicated the valuable work done by the Council not merely in the interests of members but in the interests of the Gas Industry as a whole. Having read the Address and studied the chart it should be very much easier for the Society to make out a good case why prospective members should join their ranks. Although he had the honour of being the Chairman of one of the Sections of the Society, he used only to have a very sketchy idea of the real activities of the Society as a whole. But immediately he was privileged to assist in the deliberations of the Council he realized to the full the importance and value of the work it was doing on behalf of all of them. That was some five or six years ago, and since then—and particularly during the last few years, since the inception of the B.G.F.—the activities of their Society had enormously increased. And he saw every sign that these activities would be continued. Mr. Rogers was the right man to place such an Address before them that day by reason of his unique and lengthy experience in connection with both the supply and appliance-manufacturing sides of the Industry. They owed him a very hearty vote of thanks for the time and thought he had expended in presenting them with this complete picture of the Society's activities.

Mr. C. G. DAVIS, in seconding the vote of thanks, endorsed all that Col. Planck had said in regard to Mr. Rogers' instructive and comprehensive Address. He had a very wide knowledge of the Gas Industry; he was a man of outstanding ability, from whom they expected an Address of a high standard, and he had not let them down. Mr. Davis went on to say he was glad Mr. Rogers had called attention to the pioneer work of Mr. Charles Claire; many of them did not appreciate the great services which Mr. Claire had rendered to the Industry when he started the Society of British Gas Industries in 1905 with a very able and hard-working lieutenant in Mr. A. L. Griffith. To them they owed a great deal for the firm basis on which the Society had been built up. He was also glad to hear their Chairman's reference to the proposed permanent gas exhibit at the South Kensington Science Museum. The Council, through the energies of Mr. Henshaw, were most desirous of giving this the fullest support, as they realized the great opportunity which was thus presented to them and the whole Industry of showing the public the important part the Gas Industry played in the national life of the country. They might not be aware of the fact that over a million people visited the Science Museum each year, from which they would realize how important it was to give this project the fullest possible support.

The vote of thanks was heartily accorded, and Mr. ROGERS made brief acknowledgment.

A Tribute to the President.

Mr. ERNEST WEST proposed a vote of thanks to Sir Harold Hartley for presiding over the meeting. They were delighted that he had been able to spare the time, in spite of the many calls upon his services, to join them and give them the benefit of his leadership. Knowing his interests in the scientific world and in research activities connected with the national use of fuels made them very proud to have him as their leader, and they were confident that the efforts they were making to build up and co-ordinate the Industry would achieve greater success under his able guidance.

Mr. R. P. CHESTER, in seconding the vote, said that the Society was very pleased and proud to have Sir Harold as their President this year—not only because of his vast knowledge of scientific and research work, but also because of his enthusiasm and driving power in the cause of any organization with which he became associated. In these troublous days of world upheaval it was gratifying to the country as a whole to have him as Chairman of the World Power Conference, while they also appreciated the valuable work which was being done by the Fuel Research Board under his chairmanship.

In acknowledging the vote of thanks, which was heartily accorded, Sir HAROLD HARTLEY remarked that it was a great pleasure to be with them that day and to have the opportunity of meeting many of the members, as well as being present when they passed the resolution to admit the coke oven interests to their ranks, and also to have the opportunity of listening to Mr. Rogers' masterly Address. He admired the skill with which Mr. Rogers covered in so short a compass so many of the problems which the Industry had to face; he gave them the picture of those problems in extraordinarily clear perspective. In these busy days, when they had so little time for reflection, it was of advantage to all to listen occasionally to Addresses like this, when all their problems were brought together and focused so lucidly that they could go away with a clear view of the matters before them; and then when they came to their deliberations, subconsciously much of what he had said would be in their minds and would influence their discussions.

The S.B.G.I. Luncheon

At the informal luncheon which preceded the Autumn Meeting of the Society the PRESIDENT, Sir Harold Hartley, presided, and was supported by Mr. R. J. Rogers (Chairman of the Council) and by a number of Past-Chairmen.

The Loyal Toast having been duly honoured,

Dr. E. W. SMITH proposed "Our President," remarking that this was Sir Harold Hartley's first appearance among them in office, and they were delighted to see him. The more they came into contact with him during his year of office the better it would be for them. Sir Harold was a Director of the Gas Light and Coke Company, Vice-President of the London, Midland, and Scottish Railway, a Professor of Oxford University, a Director of *The Times*, and, most important perhaps, Chairman of the World Power Conference.

It was difficult, went on Dr. Smith, for an organization connected with a particular industry to communicate with another organization in order to obtain better co-ordination. There was no one better able to co-ordinate carbonizing interests in this country than Sir Harold; the two carbonizing industries should get together in regard to research and so eliminate duplication. Many of their problems were common, and he felt very strongly that the best future for research work in the carbonizing industry lay in better co-ordination and the formation of one or more research associations in which members from both sides could work together on similar lines. Dr. Smith saw no reason why there should not be some such research organization for the carbonization industries. Then there might well be another for utilization of fuel. The formation of a Coke Oven Section within their Society was a beginning of still greater co-ordination between the gas side and the coke oven interests. In conclusion, Dr. Smith expressed the hope that Sir Harold would have a happy time among them, and if there was anything they could do to assist him in the work he was doing for them he had only to call upon them.

The PRESIDENT thanked Dr. Smith for the charming way in which he had proposed his health. Obviously he could not know very much about all the problems with which they were concerned; but he had found on occasions that one could fulfil a useful function in being in touch with different groups and able to form a bridge between them. So often to-day, with all the progress that was being made, there was knowledge at the disposal of one organization

which was wanted by another for an entirely different purpose, and it might happen that there was no bridge by means of which that knowledge could be transferred from one to the other.

This was the first time he had had the pleasure of wearing their Presidential badge, and he greatly appreciated the honour the Society had done him in putting him in the position to wear it. He also referred to the pleasure it gave him to be present on the occasion of the constitution of a section for coke oven interests, because the first question he had asked was—"Do you really cover the whole extent of the carbonizing industry?" The carbonizing industry to-day covered the gas, coke oven, and low-temperature carbonization sides—each responsible for the treatment of their greatest national asset—coal—by various methods in order to give different products; and each played an important part in the national economy. It was a great satisfaction to feel that with the formation of this new section they had covered the whole carbonizing industry; and, secondly, the research problems acquired a wider significance because they had the whole range of treatments, and they wanted to get all the value from research generally applicable to any of their problems. So far as research went, Sir Harold was in favour of a number of separate units, where there was a greater opportunity for individual initiative than one could get in one large combined unit. Progress in research depended upon individual brains, and they wanted to put individual brains where they would have a certain amount of freedom, while, on the other hand, they wanted some method of co-ordination to ensure that there was no wasted effort. What they wanted, therefore, was some means of securing a pooling of results over the whole field. So far as the Fuel Research Board was concerned, all its resources were available to them. The Board could claim that it did keep in the closest touch with industry. The Board's job was to know industry's problems and to try to give help where possible in solving them.

In conclusion, the President thanked Dr. Smith once again for the very kind way in which he proposed the toast, and the Society for the honour they had done him. He had a very sincere and real interest in the objects of their Society, and anything he could do at any time he would do with the greatest of pleasure and satisfaction.

S.B.G.I. Golfing Circle.

At the Autumn Meeting of the Society of British Gas Industries Golfing Circle, which was held on Wednesday, Nov. 3, on the course of the Hendon Golf Club, the Yates Bowl was won by Mr. L. J. L. Walker with a score of 2 up.

At the Annual General Meeting of the Circle, which was held during the day, the following officers and Committee were elected for 1938:

Captain—W. R. Edgar.

Committee—H. E. Bennet, H. B. Holmes, Col. O. B. F. Planck, W. H. G. Roach, H. G. Williamson, and C. R. Averill.

Decorative Lighting

Illuminating Engineering Society's New Section

To afford opportunities for the discussion of the artistic side of lighting, the Illuminating Engineering Society have formed a new Section dealing with Decorative Lighting. An attractive programme has been arranged for the present session which opens on Nov. 9 at the Institution of Mechanical Engineers, Storey's Gate, Westminster, at 6.30 p.m., with Addresses on the "Lighting of the International Exhibition in Paris" by M. J. Dourgnon and Mr. R. O. Sutherland, A.R.I.B.A.

On Dec. 10, "Problems in Decorative Lighting" will be presented by various architects. Subjects for subsequent meetings include "Relation between the Artistic Design and the Mechanical Construction of Lighting Fittings," by Mr. E. H. Penwarden; "How I would Plan the Lighting of a Home," by Miss Edna Moseley, A.R.I.B.A.; and a discussion on "Glassware in Relation to Decorative Lighting" to be opened by Mr. Oliver Bernard and Dr. W. M. Hampton.

The Decorative Lighting Section is designed to appeal to architects, designers, decorative craftsmen, and all concerned with the use of light for decoration and effect. Membership of the Section for the current session is free, and without any obligation. Readers are invited to apply for further particulars to the Hon. Secretary, Mr. D. W. Durrant, Magnet House, Kingsway, W.C. 2.

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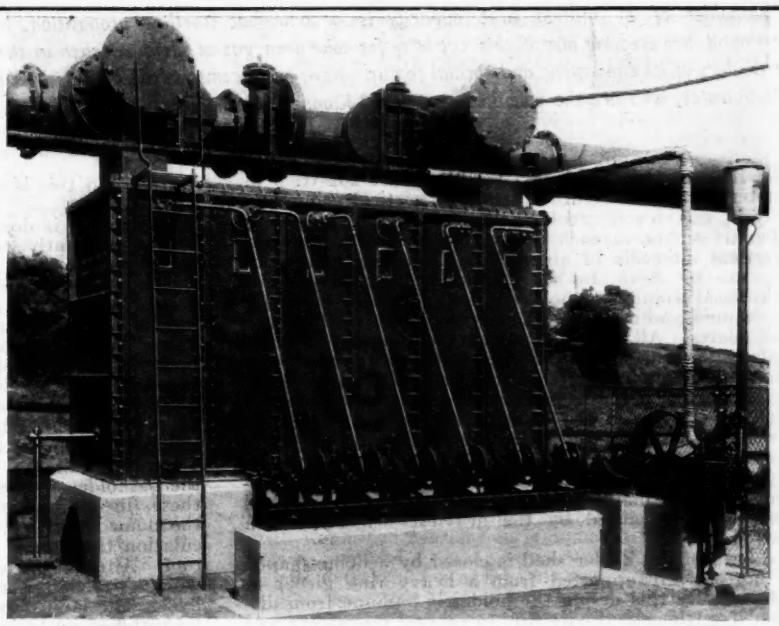

AT CHESTER

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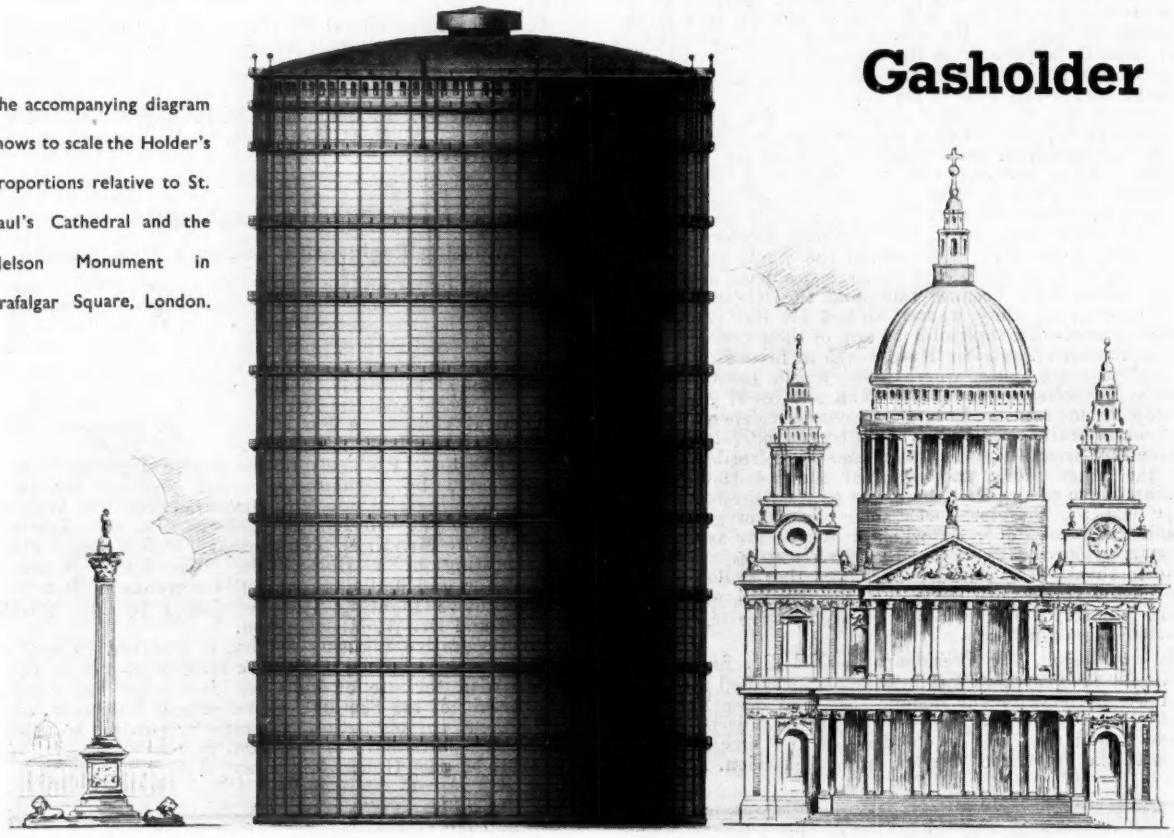
A 21-Million Cu.Ft. Waterless Gasholder

The accompanying diagram shows to scale the Holder's proportions relative to St. Paul's Cathedral and the Nelson Monument in Trafalgar Square, London.



A gasholder of 21 million cu.ft. capacity is a somewhat startling proposition, but we learn that Messrs. Klönne, of Dortmund, are erecting one of this capacity for coke oven gas at Gelsenkirchen in the Ruhr District, and the following brief particulars of its dimensions and special features have been communicated to us by Dry Gasholders, Ltd., 39, Victoria Street, Westminster, who are the sole licensees for "Klönne" Gasholders in this country. This gasholder is the largest in the world, and its weight exceeds 5,000 tons.

The shell of the holder is a steel cylinder 262 ft. 6 in. diameter by 443 ft. high. It has fifty vertical columns of steel joist and eleven circular galleries, also stiffening rings of channel section at each ring seam between the galleries at vertical intervals of about 5 ft. The side plates are 9/32 in. to 3/16 in. in thickness butt-jointed on the vertical columns, the horizontal galleries, and the ring channels, which form the cover plates for the joints of the plates. All the shell seams are welded. To hold the plates in position for welding, rivets are put in at wide pitch. These are countersunk on the inside and welded in to avoid any risk of gas leakage. The shell plates are welded together, and the columns and circular stiffeners are welded to the shell. All projections on the inside of the shell are then ground off, making the interior a perfectly smooth sliding surface. The holder framing is sufficiently stiff to maintain the circular shape of the shell under all loads caused by the heaviest winds and sun radiation.

The base of the holder shell is closed by a dome-shaped steel bottom self-supported from a heavy ring girder of box form. By this design the holder is immune from distortion if settlement occurs due to mining operations and can be easily re-levelled by raising the ring girder on its outside periphery. The domed bottom is sufficiently stiffened by rafters and rings to maintain its shape without support from below; but to exclude air the space beneath the dome is filled in with sand after the underside of the steel dome plates have been carefully painted.

Moreover, the domed bottom and ring girder are so strong that they will carry over one-third of the periphery without distortion in the event of settlement occurring.

The top of the holder shell consists of a dome-shaped roof having at its centre a large ventilating lantern. The roof is stiffened by rafters and rings, and covered with steel sheets. The ventilating lantern is so constructed that a continuous flow of air takes place inwards and outwards, and this is accelerated by the nozzle effect of the ventilators.

The piston is domed to the same radius as the bottom and is sufficiently strong to bear loads of concrete blocks to throw any desired pressure up to 12 in. water column. Partitions are provided to prevent any shifting of the concrete blocks. It is guided by wooden rollers to obviate a metal-to-metal contact.

The sealing ring on the periphery of the piston is a compound of rubber and cotton and kept in close contact with the wall of the shell by adjustable weighted levers. It is automatically grease lubricated, thus ensuring easy travel of the piston and the automatic maintenance of a protective grease film on the interior of the gasholder shell.

Large ventilators are provided at regular intervals in the gasholder shell above the limit rise of the piston, and these, in conjunction with the lantern at the centre of the domed roof, create and maintain an efficient air circulation throughout the space between the piston and the roof. Alternating with the side ventilators are numerous windows to light the interior, and these are supplemented by electric lamps enclosed in boxes on the roof which can be switched on to increase the lighting at any point when desired.

Capacity Indicator.

The gas content of the holder at all times is shown by a pointer that traverses a vertical graduated indicator board 80 ft. high and at the extreme ends of which are electric lights that automatically switch on when the piston is at its lowest or highest position. The pointer is fitted with an electric light so that its position can be seen at night from a distance; also the indications can be electrically transmitted to a dial at any distance away if so desired.

Access to each of the eleven external galleries and to the top of the gasholder is readily and safely provided by

an electric lift enclosed in a vertical tower outside the gasholder shell and by stairways which are contained in the same tower in convenient flights, with landings at each gallery. The lift is arranged to halt at each gallery and is fitted with efficient breaks, position indicators, and all equipments for safety and convenience.

Access to the top of the piston is by means of a cage with four suspension ropes, power-driven, while for emergency purposes there is a single-rope conveying seat for one man, winch operated.

As the holder is for relief purposes, only one pipe is necessary, and this is 40 in. diameter. It enters the side of the gasholder through a box, and to prevent any derangement in the event of mining settlements has a dipping fluid seal allowing a settlement of 15 in. without escape of gas.

The British Road Tar Association

Sir David Milne-Watson's Presidential Address at the Association's Tenth Annual Luncheon at Grosvenor House, Park Lane, W.1, on Nov. 4, 1937.

It is my privilege to address you to-day as your President, at this luncheon which is being held on the occasion of our Tenth Annual General Meeting.

I would like first to offer a belated, but nevertheless whole-hearted, welcome on behalf of the Tar Industry to the new Minister of Transport, Dr. Leslie Burgin.

He succeeds to this office at what is probably the most critical moment in the history of our road development. Taking up the reins from Mr. Hore-Belisha, he follows a man who succeeded in putting new vigour into the efforts to bring our road system up-to-date. With the rapidly increasing volume of road traffic of all kinds, and its lamentable toll of death and injury, the Minister of Transport is always in the public eye—probably as much as any other member of the Government. His position is, therefore, subject to continual criticism, much of which is unjustified and ill-informed.

While practically everyone is a road user, very few have any real knowledge of the complexities of the subject, or recognize that the problem of making our highways fit and safe for modern transport is one of such vast proportions that headway can only be made gradually, if we are not to make costly mistakes. The problem is never static. Road transport has grown so rapidly during the past decade, that the many roads then considered by the expert as likely to be adequate for an indefinitely long period, have already proved to be quite unequal to the demands on them. No one can foresee the rate at which this transport problem will develop in the future. The Minister of Transport has, therefore, an extremely difficult task in planning a long range programme of development, which will keep pace with traffic requirements, without waste of public money on unnecessary and expensive schemes, for which time may show that there was no justification.

Road Fund Expenditure and Road Development.

Part of the criticism against the Minister of Transport has been concerned with the financial support granted to Highway Authorities, particularly in relation to the Five Year Plan. I referred to this in some detail last year. Just two years ago the Government announced its decision to embark on a plan involving the expenditure of no less than £100,000,000. The progress of the plan has been severely criticized owing to the lag between the submission of schemes and the actual commencement of work on them. Yet I suggest that anyone who appreciates the enormous complexity of the whole problem must realize that some delay between the approval and the actual start of the work is inevitable if the money is to be wisely and economically spent. Approximately half the schemes submitted to the Ministry have now been approved, and we may, therefore, confidently anticipate the speedy progress of actual operations.

There has been a continually increasing agitation in recent months for completely new motor-ways, linking up our main centres of population on the lines of those being made in Germany. While I agree that there is undoubtedly a need for some such roads, I do not think our national transport problems will be satisfactorily surmounted solely by a network of new roads of the type proposed.

Particular prominence has been given in the last few weeks to the experience of the German Roads Delegation, which spent ten days at the end of September on a tour of inspection of the new German motor-ways. The party of over 220 strong consisted of a large number of Members of Parliament and Highway Engineers, as well as representatives of every side of the Road and Motor Industries. While it is universally admitted that the trip was a model of organization, as was only to be expected, the opinions of the participants on the road constructional aspects vary enormously. Some consider that we should immediately commence to put down a series of entirely new roads on the German plan, while others have returned with the view that except as regards new ideas for processes and machinery for rapid road construction, there is little to learn. It is interesting to note, however, that the Minister has asked the Delegation to present him with a report on the tour.

The Railways' Part.

The German problem is very different from ours. While we may certainly have something to learn, there would appear to be no justification for any attempt slavishly to copy the German example. To my mind, in considering our transport problem we cannot deal with the road aspect by itself. The position of the railways must be taken into account. For long hauls of heavy traffic the railways will always be essential, and they must be maintained in an efficient and financially sound condition.

Road and rail are complementary. Both must continue to play a vital part in the life of the community, and the development of one without reference to the other will never be in the best interests of the country. What I should like to see, and what I think we should vigorously urge, is a national long distance policy of co-ordination of road and rail, which would enable both to be developed to the national advantage. In this connection, it is interesting to note that the new German roads are being constructed by a company, which is a subsidiary of the German State Railways, and that means are apparently provided for the regulation and distribution of traffic by the two systems of transport. A scheme for the co-ordination and centralized control of all forms of transport has also recently been put into operation in France.

In this country we have already a higher mileage of road in relation to the area than any other country in the world. As I see it, the provision of adequate highways here lies possibly in the building of a few new motor roads, but principally in the modernization of our present main roads, and the intelligent adaptation of our secondary roads to form an efficient network of good auxiliary routes, which will be of great value in relieving our main roads of much of the short distance traffic. This development is vital in itself, and would not be obviated even if a net-work of new motor-ways were provided.

Tar and Road Construction.

Let us now consider the part which tar will play in our road development programme and the work which the British Road Tar Association is doing to help to solve the problems involved.

In the agitation for new roads and new road surfaces, it is often forgotten that as far as safe, durable, and comfortable road surfaces are concerned, the roads of this country, taken as a whole, are superior to those of any other country, whatever may be their other shortcomings. With the advent of the motor car at the beginning of this century, there naturally came a demand for better surfaces, and this was met by the use of tar. Until a few years ago, tar was unchallenged in this field, so that it can justly claim the major share of the credit for the fine road surfaces in this country. Tar has now two important competitors—bitumen and concrete. This has promoted a healthy rivalry, which has led to intensive research and experimental work, and has brought about a rapid development in the utilization of these various materials for road construction. This is as it should be. We are all users of the road to a greater or less degree, and we all

want better and safer surfaces. It is clear that tar, bitumen, and concrete each can play a valuable rôle in meeting the various demands imposed by modern heavy traffic.

It is gratifying to note that in the last year or two, the use of tar is on the up-grade, in spite of the increased life which is being obtained from tarred surfaces, and the competition of our rivals. Tar has been with us a long time, as I have already said. Familiarity is apt to breed contempt, and in many quarters tar is regarded as just a black, sticky substance. May I remind you that tar, the product of our native coal, derived from our native gas-works and coke ovens, in addition to its use on roads and in road construction, has been responsible for more new and epoch making industries than any other single raw material. Our dyestuffs, explosives, fine chemical, disinfectant, and plastic industries, to mention only a few—all of comparatively recent origin—are based on tar. Tar is a complex material of enormous potentialities, and the investigation work both in the laboratory and in practice on the road, which has been sponsored by the British Road Tar Association and its members, as well as the experimental work of the Ministry of Transport, indicate that in tar, prepared and applied by the most up-to-date methods, we have a material, capable of satisfying all the demands of our Highway Engineers.

There are in existence, tarmacadam roads which have lasted at least thirty years, while a normal life of at least fifteen years can be expected under most conditions. Surface dressing with tar, which was once an annual affair, has now been so improved that a life of three to five years can be assured. One of the main duties of the British Road Tar Association is to see that this progressive development continues unabated, not only in regard to the quality of the tar itself, but also in regard to the technique for its use in road construction—an aspect to which all concerned should give even more attention than they have done in the past.

We have every confidence that as our knowledge and experience increase, we will continue to be able to supply a product which will meet the most exacting specifications of the Road Engineer; which will give a road that will be safe and comfortable to drive on under all weather conditions; and which will at the same time be economical to construct and maintain.

We have, therefore, every confidence that tar will continue to maintain its position as our most valuable and ubiquitous road material.

In conclusion I wish to pay a tribute to the work of the late Chairman, Sir Reginald Clarry, during his seven years' association with our organization. When he tendered his resignation early this year, we accepted it with the greatest regret, as we realized how much the British Road Tar Association owed to his wise and tactful guidance. We wish him every success in his future activities. At the same time, we warmly welcome his successor, Mr. J. Davidson Pratt, the distinguished General Manager of the Association of British Chemical Manufacturers, whom we assure of our loyal support.

Malta and Mediterranean Gas Company

Extraordinary Meeting

An Extraordinary General Meeting of this Company was held at Winchester House, Old Broad Street, London, on Tuesday, Nov. 2, 1937, to consider ordinary and special resolutions relating to the Capital of the Company and also the Articles of Association. Mr. A. M. PADDON (Chairman of the Company) presided.

The SECRETARY having read the notice convening the meeting,

The CHAIRMAN said: Each stockholder has been provided with these resolutions as read out in detail so that they have had time to consider them in every way. Those among you who have had experience of these matters will realize that the resolutions have been drafted with great care and with the cognizance of Counsel and others who are able to authenticate the resolutions as they are worded. You can hardly be expected to have followed them as they were read.

This meeting has really been convened by the Directors from a dual sense of responsibility; first, to acquaint you with the changes in the ordinary circumstances of the Company that have supervened during the last ten years or so, and, secondly, to provide you with such a proposal as may be calculated to meet these changes and to restore the stability of the Company so far as it is practicable to do so. I do not propose to take you through the details furnished you in the statement which each proprietor has received, but rather to refer to the matter *in extenso* in general terms. The main facts actuating our proposed policy in this regard are these. For nearly fifty years the capital of the Company has stood at the figure at which you see it in the accounts to-day—roughly speaking, about £123,000. At one time the business of the Company was nearly double what it is to-day; in other words, we sold 120 million cu.ft. of gas a year whereas to-day we are only able to register 68 million cu.ft. per annum. That is partly due to the fact that we have parted with certain concessions of the Company, such as Trapani and Marsala, and these have reduced the bulk of the Company's output. This is rather by way of release for damnification, because our obligations under these concessions were very perilous in the event of our being called upon to fulfil them, and by the skill of direction of a former Chairman of this Company, Mr. Arthur Phillips, we were able to extricate ourselves from these obligations with the result that the earning power of the Company by way of profit was very largely developed and augmented. That, supplemented by favourable circumstances, enabled us to declare the very handsome dividends to which you have been accustomed—namely, 10% free of income-tax and the 7% and 7½% prior charges.

You all know that this business has at all times been dependent upon the political, naval, and military dispositions in the Mediterranean. Our fortunes have been bound up with them; but during the last four or five years—and this is as well-known to you as it is to me—there has been a violent disturbance in that sphere, which has militated to a considerable extent against us. Therefore, due to the falling business of the Company, entirely occasioned by adventitious and almost fortuitous circumstances, we find ourselves in the position that we cannot quite continue to pay upon such a large unrevised capital the dividends and interest we have been paying hitherto, in the light of our reduced business. That is, therefore, the main ground for the proposition which we are submitting to you to-day.

As you have been acquainted from our balance-sheets and statements for many years past, the capital of this Company has been set off against an accumulation more than equal to its nominal value. The actual figures you know quite well; they amount to about £160,000 against a capital liability of £123,000. That money accumulated partly by way of interest which is available for dividends now at the rate of something like 2½% to 3% per annum and if this proposition which we are putting before you to-day is adopted it will be applied to extinguishing part of the current liability of 7% and 7½% upon the preference stocks and 10% free of income-tax upon the ordinary stock, which is obviously a much more economical and practical use of the money. At the same time, if this resolution is adopted by you—and I think we have the measure of support already from the stockholders to enable us to pass this proposition—the capital investment of the Company will be reduced to £85,000 as against a liability of £74,000, and therefore the redemption potentialities of the Company will not be reduced. We shall still have, in the amount left, a margin necessary to redeem the capital at the end of the Concession. You must realize that this Concession has only 14 or 15 years to run, and we cannot give you any assurance of its renewal. But that is justification for the policy in the past of providing, at the end of the Concession, for the return of the capital. Whether the capital remains as it is or whether it is reduced we still have the potentiality of redeeming it. I can assure you that we have taken very careful legal advice on this matter, because it was incumbent upon us to do so, and we are assured that the preference stockholders and the ordinary stockholders will have an equal claim to the distribution of the assets at the conclusion of the Company's Concession or when it is finally disposed of. If this proposal is carried out it will leave three-fifths of the capital, and it will relieve the Company of having to pay these big dividends of 10%, 7%, and 7½% in the ratio of two-fifths. It will stabilize conditions and, we hope, allow us to maintain the present dividends on the capital so reserved.

With regard to the return to you, you will get your original capital and 35% in cash as premium, if you are a preference stockholder, and the ordinary stockholders will get their capital returned and a premium of 60% in cash. If these amounts were invested at the present day they would go very largely to supply whatever you may have lost by the reduction in the original capital. I think that will be admitted without any question at all; and, at the same time, it will lighten the ship as regards its obligations with regard to earning profits. In these circumstances, the Company will have a far more definite expectancy of the dividends it has been paying.

That sets out, in as few words as I can, the actual policy of the Company. The details of the figures have been given to you, and I pay your intelligence the compliment of assuming that you have studied them carefully, because it is a very important matter. Will the Secretary tell us what is the present market value of the preference stocks?

The SECRETARY: Approximately £120 for every £100 of stock.

The CHAIRMAN: We are returning £135 and that is a premium of 15. What does the ordinary stock stand at?

The SECRETARY: Between £150 and £160.

The CHAIRMAN: You see there is a small premium on the ordinary stock. We have not been guided solely by our own

experience in gas matters nor our own perceptions and intelligence. As you will see from the facts submitted to you, we have subjected the proposal to the very highest form of accountancy available, and we have also submitted it to Members of the Stock Exchange, and their point of view, which is not necessarily ours, is that there are no features to which any reasonable exception could be taken. Therefore, we have been re-assured from both points of view—*i.e.*, market value—of course, any reduction in the rate of dividend would be reflected in the market value—and general accountancy—that these proposals are commendable, and we submit them to you for your acceptance as the best we can do. We are not at all without hope that we shall be able to re-establish the Company, and under the conditions with which we are confronted due to the troubles in the Mediterranean we think we are pursuing the right policy. We have under contract now coal at low prices which will last us until 1940. We bought the coal at low prices and whether we have been wise will be seen later. That it will be so I am quite certain, for to-day we have to pay freight which is twice as much as we paid a year or fifteen months ago, and that must have its effect on our revenue account. Therefore, you will see what has been behind all this matter. I think I have put the case fairly clearly to you; but if there is anything you want to know we shall be happy to give you the information.

I have pleasure in moving that the Resolution which has been read to you be received and adopted.

Mr. A. W. Oke: I beg to second this resolution so clearly put before you by the Chairman. I would remind you that this is a most favourable opportunity for this to take place. You are getting a good return on the money that is being paid back, and if you take my advice as a solicitor you will put it on morigage for a time and then you will be able to put it back into gilt edge securities if you desire to do so later on.

No questions were asked and the resolution was put to the meeting and carried *nem. con.*

The Chairman: I think the Secretary had better tell us the voting power behind these resolutions.

The Secretary: We have received proxies in favour as follows: 77% of the ordinary stock; 72% of the first preference stock; and 79% of the second preference stock, making 76% of all classes—these figures refer respectively to the total issued capital in each case.

The Chairman: The requirements of our Articles are that this resolution should be approved by 75% of the proprietors present in person or by proxy, and you will see that that condition is completely fulfilled. That is all that we have convened this meeting for and we thank you very much for attending.

Mr. A. D. Dodgson: Will there be any further meeting necessary?

The Chairman: No; not according to the Articles.

Mr. Dodgson: Then the matter will come before the Courts in due course?

The Chairman: Yes.

Mr. Dodgson: Can you tell us when that is likely to be?

The Chairman: If you knew the Courts as well as I do you will appreciate that it is rather difficult to answer that question.

Mr. Dodgson: Is it a matter of months?

The Chairman: We shall have to get the case set down in the Chancery Court, and it all depends on the business which the Courts have to deal with. I should say that we might get it dealt with in the early part of next year. The fault will not be with us if there is any considerable delay.

Mr. F. R. Smith: I should like to propose a vote of thanks to the Board in connection with this resolution. I think myself it is a very wise step to take, especially considering the uncertain state of things so far as the Mediterranean is concerned. I think the Directors have been very wise in doing what they have done.

Mr. Dodgson seconded the vote of thanks, which was carried unanimously.

The Chairman: We thank you very much indeed for your kind vote of thanks. I can assure you that we have gone to a great deal of trouble in this matter both on the part of our legal advisers, and also in regard to the accountancy of what we have put before you. Our reward is that you are satisfied with what we have done.

The meeting then closed.

NOTES ON

Thermostatic Controls for Coke-Fired Boilers

We publish below the discussion which followed Mr. L. H. Ardley's Paper to the London and Counties Coke Salesmen's Circle—see last week's "JOURNAL," page 358.

Opening the discussion, the Chairman congratulated Mr. Ardley on presenting a subject which was becoming more and more important every day. It was his view that a great deal of the success which accompanied their attempts to capture the coke central heating load was dependent upon the extent to which they could apply thermostatic control.

Dr. F. J. Eaton (Gas Light and Coke Company) said the subject had been treated in a very practical way and the Paper should do much to encourage the more extended use of thermostatic controls. It was now accepted practice in any gravity-feed boiler installation to fit thermostatic controls, but very little progress had been made where hand-fired central heating boilers were fitted, while of the thousands of domestic boilers sold each year not 1% were fitted with any automatic device for controlling the rate of combustion. It was well to remember that thermostatic control was introduced when coke sales for central heating were declining due to the growing competition with oil fuel, and it would appear logical to continue in prosperous times a policy which had proved efficacious when trade was not so good.

Control of combustion was essential in any fuel-burning appliance, and in general it was better to rely on the automatic control provided by a thermostat than on the variable personal factor of the boiler room attendant. While the saving in fuel due to the automatic control varied according to the skill previously exercised by the stoker there was in general a definite saving in fuel, better service was obtained from the boiler, and the attention required was less. In the early experiments made at the Fulham Laboratory of the Gas Light and Coke Company, in which only a boiler thermostat with automatic damper control by fractional horse power motor was fitted, overheating of the building was avoided by setting the thermostat according to the mean shade temperature between 7 and 9 a.m. Use was made of the equation-thermostat setting = 270 − 3 × mean shade temperature. This was a simple system which could be applied to any hand-fired central heating boiler. Since the days of these early experiments various improvements had been introduced in the controls used to operate the dampers, and a control which automatically set the dampers in a safe position, when for any reason the motive power failed, was to be recommended. The advantage to be gained by fitting some form of balanced draught chimney damper should not be overlooked. Such a damper ensured, no matter what the flue gas temperature or atmospheric conditions, a constant chimney pull at the flue outlet of the boiler and was just as important and served the same function as a governor fitted to a gas appliance.

He (Dr. Eaton) thought they should differentiate between the type of control for central heating and that for the provision of domestic hot water. For the latter thermostatic controls were practically non-existent—the only types used incorporated pressure bellows which while satisfactory under pressure quickly deteriorated under tension. Moreover, this type of control was too accessible to inquisitive people, and for that reason it did not last very long. There had recently been put on the market some gravity-feed domestic boilers which were designed on the right lines; these boilers were supplied with chimney dampers of a very simple type. It consisted of an opening fitted with an aluminium flap which was carefully pivoted. The ash-pit door fitted tightly, the air for combustion entering through a hole in the side of the boiler, which was of a definite size as related to the flue pull and the size of the chimney regulator. The thermostat operated a flap, which opened and closed the hole under the ash-pit. With these boilers, which were intended for hot water supply, the positioning of the thermostat was important. For hot water supply, where ample supply of hot water was required the thermostat should be placed on the return service, where the cold water going back to the boiler immediately operated the control, and the combustion rate was increased to replace the hot water drawn off. So far as the domestic market was concerned there was at present a great opportunity for increasing the service to the public by the introduction of some type of control which was reasonably cheap. At the moment they were expensive; one could get nothing under £2 5s. *plus* the fixing charges, whereas they should aim at about 30s.

Mr. Ardley agreed with Dr. Eaton's remarks regarding draught stabilizers and pointed out that a control of the "on and off" type could not compensate entirely for variations in draught due to variations in wind, &c. He also agreed with his remarks on pressure bellows thermostats.

Mr. W. L. Boon (Manager of the L. & C.C.A.) said that a Paper of this kind before a Circle of that character was going to be very useful in the specific ways in which they could apply it. They were all interested in the selling of coke, though only a few of them were technical people. Nevertheless, they wanted to understand the methods and reasons whereby thermostatic control could be applied. There were two specific considerations from the salesman's point of view. One was the aspect of

economy. If we are to maintain a proper price level for our coke in the future, it is necessary to give the consumer an optimum service from the fuel. By such means as those outlined by Mr. Ardley could that aim be achieved? Without consumer's satisfaction they could not maintain progressive sales. The other aspect was that of convenience. This was nebulous in assessment, but it was one for which everybody was paying a great deal of money. If a small domestic boiler could be developed with a simple form of automatic control whereby economy and convenience were achieved, they would go a long way towards improving their position in this important coke market. There was a stove on the market at the present time (not operated by coke) embodying a very simple and efficient method of control. They must not only tackle the larger installations from the aspect of automatic control, but the smaller ones as well, for they had a much greater market for the smaller boiler. In conclusion, Mr. Boon asked why Mr. Ardley had not mentioned the use of clock control mechanism as was used in the United States.

Mr. ARDLEY replied that he had mentioned clock controls in a general way when referring to day and night room thermostats and variostats. Clocks are also frequently used changing the sequence of operations in multi-control installations and for week-end shut down of shop and office plants.

He agreed that thermostatic control of domestic boilers was not only advantageous but necessary, but thought that this matter rested more with the boiler makers than with the makers of controls, because very few of the smaller boilers had suitable dampers conveniently placed for the proper application of controls, while the boilers themselves were subject to air leaks which made satisfactory control almost impossible. There were, however, one or two boilers now on the market which have been specially designed for automatic control.

The CHAIRMAN asked for information in regard to the choice of the key room with a view to obtaining the best operation of the boiler system.

Mr. ARDLEY said that this was a very difficult point because it varied so much between one building and another—*i.e.*, the aspect, height of room, &c. In large buildings it was almost impossible to find a room which would give a true average temperature of the whole premises; the best position was usually a room somewhere about the middle of the block as a whole. But it must be understood that it would seldom give a truly mean temperature. A first or second floor corridor, provided it was not subject to draughts from outside, was usually as good as anywhere.

A question was raised whether they, as coke salesmen, were expected to sell coke at a higher price as well as apparatus to control the cheaper type of boiler. Had the coke salesman got to develop thermostatic control?

Mr. Ardley said it was not his intention to discuss automatic control as an aid to coke sales, although they were an aid to coke sales in that they increased economy and convenience in coke usage. Some time ago—when coke was a definite by-product—they wanted means of competing with oil, one of whose selling points was automatic control; so they set out to make coke automatic as well. Gravity-feed boilers and thermostatic controls were developed for that reason, but the argument still held good although that competition no longer existed. For very small domestic boilers, however, the present cost of controls was usually too high to justify their adoption. But for boilers using ten tons of coke a year and upwards the fitting of controls was usually warranted by convenience and safety, if not of economy.

The CHAIRMAN said that they must regard automatic controls as an aid to coke sales and in meeting competition.

A MEMBER said that many present at the meeting were not technical men, yet they must have some understanding of the subject of automatic controls if they were to use them as an aid to sales. Otherwise they could not go to a consumer and tell him what could be done. He suggested that particulars of the simple chimney draught control should be given. He also asked if the Author could tell them what fluid was generally used in the expansion bellows of thermostatic elements.

Mr. ARDLEY said that the best way to describe the chimney damper control was to imagine that a rectangular hole was cut in the chimney stack, and this was covered by a very light aluminium plate carried on pivots, so that it was sensible to very slight draught changes. It is set so that a small draught is just sufficient to close the hole, but if the draught increased due to a higher temperature in the stack, a lower outside temperature, or wind variations, it would cause the plate to open and admit air into the flue, which by cooling the hot gases would check the increased draught, and thus maintain a constant pull at the boiler. It was usually possible to fit such a device to any chimney, and where variations in draught caused trouble the coke salesman could well recommend its adoption.

Dr. EATON, replying to the question regarding the type of fluid used in the bellows, said that in general a low-boiling petroleum fraction was used.

The CHAIRMAN said that there was really nothing new in this matter of draught regulation. Twenty years ago it was a common feature of all retort settings, a regulator being inserted in the main flue with a counter-balanced door set slightly open for normal conditons. In a high wind it opened wider and reduced the draught to normal conditions. Since the introduction of mechanical draught, however, such devices had fallen into disuse; but it was usual to effect a 10% reduction in fuel by utilizing such a device. They had been in use for sixty or seventy years.

Another MEMBER stated that the Paper clearly indicated that the need for thermostatic control on solid fuel appliances was very real. Moreover, the price of coke having approached an economic price level, any appliance that could increase plant efficiency was of benefit to the coke user, and should therefore be advocated by all those connected with the marketing of gas coke. He thought, therefore, that any exploitation of prices on the part of those concerned in the installation of the thermo controls should be deprecated. Some two years ago the price of standard thermostatic control to a gravity-feed boiler was between £21 to £23, and accordingly any such type of boiler installed was usually so equipped. He had occasion quite recently to specify a similar installation, where the price quoted by the commercial undertaking approached was £45. It was thus becoming understandable why a number of gravity-feed boilers were now being installed without a reliable system of control.

He asked the opinion of the Author on control by hydraulic means, and whether such a medium had advantages over electrically operated controls. Such a system with main water, or local cold water tank pressure—*i.e.*, 15 lb. per sq.in.—has now been tested, and it was found that the ensuing control was pracically "floating." That is to say, the fluctuation in regulated temperatures between "on and off" had reduced the differential to nearly $\pm 1°$, whereas with the standard electrical equipment the differential is often of the order of 6°. The use of water control provides a large increase in power which is particularly desirable in places where boiler dampers are prone to stick in the open position, either through ill fitting or expansion by heat. The consumption of water is approximately one gallon per hour when dampers are shut, and the running cost is therefore low. Furthermore, there appears to be less liability of breakdown than with electrically operated controls.

Mr. ARDLEY said that it was difficult to estimate costs exactly without surveying the job, but he considered that an average electrical boiler control would cost about £25 to £30. Regarding hydraulic controls, he agreed that they had a very useful field, but did not consider that their advantages over electrical controls, save on the ground of current failure, justified their higher capital and installation costs, except for large installations. A special water rate might also be demanded by the water undertaking.

In answer to an enquiry as to what might be the actual saving to the consumer by the adoption of automatic control, Mr. Ardley replied that it depended upon the running and stoking of the boiler. It was unwise to guarantee any saving. A boiler of under 50,000 B.Th.U. per hour was not worth controlling except on the grounds of convenience and safety. Even 100,000 B.Th.U. was on the small size to obtain any appreciable saving. Anything above that, however, usually justified control.

The "Fifth" Celebrations at Cambridge

First Round to Mr. Rioch

An outstanding feature of this year's Guy Fawkes "rag" at Cambridge was the notable victory scored by the Cambridge University and Town Gas Light Company! In these affairs, public street lamps seem to hold a magnetic attraction, and climbing a standard finally to extinguish the light is considered a feat of superb merit. Sometimes much damage is caused by the flinging of fireworks and coins, and the smashing of a lamp presents no great difficulty to those whose aim is passably accurate.

On this occasion, however, the Company struck the first blow, and by means of barbed wire entanglements surrounding the higher standards defeated the object of the more adventurous climbers. In addition, special wire cages were fitted to protect the globes, with the result that during the whole of the evening only three lamps were damaged, and in no single instance was one extinguished. The Company are not prepared to state that damage was altogether negligible—but it wasn't the lamps that suffered!

The *Cambridge Daily News* comments, "The Battle of the Lamps was again the central feature of the celebrations, and this year for the first time victory went to the Cambridge University and Town Gas Light Company."

Gas Markets and Manufactures

Stock Market Report

(For Stock and Share Lists, see later pages)

The strength of the gilt-edged section was again the chief feature of Stock Exchange business last week while elsewhere, with irregular movements on Wall Street persisting, conditions were dull and uninteresting. British Funds moved up from 1½ to 2 points each, but the current prices are still well below the highest reached this year. Industrials were particularly weak, increases in value being conspicuous by their absence. One other bright spot was the Kaffir market where some of the dividend-paying gold mining shares made good progress. Metals on the other hand reacted severely and rubber was also down.

The volume of business in the Gas Market was on a slightly increased scale and spread over a wider range of securities. Prices, however, remained practically unchanged, the only alteration of note being a further small increase in Gas Light units, which hardened 3d. to 24s. 9d.

At the time of writing there is a fairly comprehensive range of ordinary and preference gas stocks and shares on offer, but, with the exception of a few large parcels, the debenture list of available supplies is somewhat limited. The latter includes £5,000 Associated Gas and Water 3½% (redeemable 1955/61 at par or 1951/55 at 102) offered at 97, giving a gross flat yield of £3 12s. 2d., and £26,000 Gas Consolidation 3½% (redeemable 1961 at par or after 1946 at 102) at the same price, while £50,000 United Kingdom 3½% (redeemable 1960 at 102) is offered at 97⅜, giving a return of £3 11s. 6d.

At a meeting of the United Kingdom Gas Corporation, Ltd., held last week resolutions were passed authorizing an increase in the capital of the Company to £6,000,000 by the creation of 500,000 4½% 1st cumulative preference shares, 500,000 4% 1st redeemable cumulative preference shares, and 1,000,000 £1 ordinary shares.

The Directors of Gas Consolidation have declared interim dividends as follows: 2½% on the "A" ordinary shares and 2% on the "B" ordinary shares, both payable on Dec. 1. These rates are the same as those paid a year ago.

Current Sales of Gas Products

The London Market for Tar Products.

LONDON, *Nov.* 8.

There are no changes to report in the prices of Tar Products in the London market, which remain as under:

Pitch, 38s. per ton f.o.b.
Creosote, 6d. to 6¼d.
Refined tar, 3⅜d.
Pure toluole, about 2s. 5d.; pure benzole, 1s. 9d.; 95/160 solvent naphtha, 1s. 8d.; 90/160 pyridine, 11s. to 12s.; all per gallon naked at makers' works.

Tar Products in the Provinces.

Nov. 9.

The average prices of gas-works products during the week were: Gas-works tar, 24s. 3d. to 29s. 3d. Pitch—East Coast, 37s. to 38s. 6d. f.o.b. West Coast—Manchester, Liverpool, Clyde, 37s. to 38s. 6d.* Toluole, naked, North, 1s. 8d. to 1s. 9d. Coal tar, crude naphtha, in bulk, North, 8d. to 8½d. Solvent naphtha, naked, North, 1s. 5½d. to 1s. 6d. Heavy naphtha, North, 1s. 3d. to 1s. 3½d. Creosote, *ex* works, in bulk, North, liquid and salty, 5d. to 5½d.; low gravity, 4⅜d. to 4½d. Heavy oils, in bulk, North, 5d. to 5¼d. Carbolic acid 60's, 4s. 1½d. to 4s. 3d. Naphthalene, £15 to £18. Salts, 80s. to 85s., bags included. Anthracene, "A" quality, 4½d. to 4¾d. per minimum 40% purely nominal; "B" quality unsalable.

* All prices for pitch are now quoted on the basis of f.o.b. In order to arrive at the f.a.s. value at any port it will be necessary to deduct the loading costs and the tolls whatever they may be.

Tar Products in Scotland.

GLASGOW, *Nov.* 6.

New business is still rather difficult, but, on the whole, prices are well maintained.

Crude gas-works tar.—Actual value is 37s. to 38s. per ton *ex* works in bulk.

Pitch remains inactive at round 30s. to 32s. 6d. per ton f.o.b. Glasgow for export, and 30s. per ton *ex* works in bulk for home trade.

Refined tar is being maintained at 3d. to 3½d. per gallon free on rails for export, and 3½d. to 3¾d. per gallon *ex* works in buyers' packages for home trade.

Creosote oil is changing hands in fair quantities at the following prices: Specification oil, 5½d. to 5⅝d. per gallon; low gravity, 6¼d. to 6½d. per gallon; neutral oil, 5¼d. to 5½d. per gallon; all *ex* works in bulk.

Cresylic acid.—There is still very little business being conducted in this product and quotations are lower as under: Pale, 97/99%, 3s. 6d. to 3s. 8d. per gallon; dark, 97/99%, 3s. 3d. to 3s. 6d. per gallon; and pale, 99/100%, 4s. to 4s. 6d. per gallon; all *ex* works in buyers' packages.

Crude naphtha.—Available supplies command round 6d. to 6½d. per gallon *ex* works in bulk, according to quality and district.

Solvent naphtha is valued at 1s. 5d. to 1s. 6d. per gallon for 90/160 grade, and 1s. to 1s. 1d. per gallon for 90/190 heavy naphtha.

Motor benzole can be secured at 1s. 4d. to 1s. 4½d. per gallon.

Pyridine.—Supplies are very scarce, with values nominal at 11s. to 12s. per gallon for 90/160 grade, and 12s. to 13s. per gallon for 90/140 grade.

Benzole Prices.

These are considered to be the market prices for benzole at the present time:

	s.	d.		s.	d.	
Crude benzole	0	9½	to	0	10	per gallon at works
Motor ,,	1	3	,,	1	3½	,, ,, ,,
90% ,,	1	4	,,	1	4½	,, ,, ,,
Pure ,,	1	8	,,	1	8½	,, ,, ,,

Contracts Advertised To-Day

Lubricating Oils and Grease.

Carlisle Gas Department. [p. 546.]

Purchase of Surplus Tar.

Carlisle Gas Department. [p. 546.]
Burton-upon-Trent Gas Department. [p. 546.]

Trade Notes

Thos. W. Ward Acquire Haslam Foundry.

Thos. W. Ward, Ltd., Engineers, shipbreakers, scrap merchants, &c., have purchased the works and plant, but not the goodwill, of the Haslam Foundry and Engineering Company, Ltd. The factory covers an area of approximately five acres in Derby, within easy reach of the London, Midland, and Scottish Railway.

THE GLOVER-WEST SYSTEM

GETS THE MOST OUT OF THE COAL

The ease with which heat can be concentrated or distributed at will in the Glover-West vertical retort setting makes possible just that heat treatment required by the particular gas coals available. And this applies to recognised carbonizing coals throughout the world. Many of them have been investigated under full-scale working conditions in the test installation on the research gas plant at our Manchester works.

GLOVER-WEST

CONTINUOUS CARBONIZATION IN VERTICAL RETORTS

WEST'S GAS IMPROVEMENT CO. LTD • MILES PLATTING • MANCHESTER 10

STOCK AND SHARE LIST

Official Quotations on the London Stock Exchange

Issue. £	Stock or Share	When ex-Dividend.	Dividends. Prev. Hf. Yr. % p.a.	Dividends. Last Hf. Yr. % p.a.	NAME.	Quotations Nov. 5.	Rise or Fall on Week.	Transaction Lowest and Highest Prices During the Week.
1,767,439	Stk.	Sept. 6	8	8	Alliance & Dublin Ord. ...	165—170	...	170
374,000	,,	June 21	4	4	Do. 4 p.c. Deb. ...	95—100	...	...
558,890	,,	Aug. 9	7	7	Barnet Ord. 7 p.c.	158—163	...	...
300,000	1	Oct. 4	1/9⅜	1/4⅜	Bombay, Ltd.	26/—28/-	...	...
179,915	Stk.	Aug. 9	9½	9½	Bournemouth sliding scale ...	200—205	...	203—205
590,407	,,	,,	7		Do. 7 p.c. max. ...	158—163	...	160—161½
493,960	,,	,,	5½	6	Do. 6 p.c. Pref ...	133—138	...	134½—136
50,000	,,	June 21		3	Do. 3 p.c. Deb. ...	79—84	...	...
262,025	,,	,,	4	4	Do. 4 p.c. Deb. ...	98—103	...	100—101½
335,000	,,	,,	5	5	Do. 5 p.c. Deb. ...	116—121	...	...
357,900	,,	Aug. 9	7½	7½	Brighton, &c., 6 p.c. Con. ...	150—155	...	153
649,955	,,	,,	6½	6½	Do. 5 p.c. Con. ...	133—138	...	135
205,500	,,	,,	6	6	Do. 6 p.c. 'B' Pref.	127—133	...	...
855,000	,,	Sept. 20	8	7	British Ord.	146—151	...	...
100,000	,,	June 21	7	7	Do. 7 p.c. Pref.	140—145	...	143½—145
350,000	,,	,,	5½	5½	Do. 5½ p.c. 'B' Cum. Pref.	110—115	...	112½—112¾
120,000	,,	June 7	4	4	Do. 4 p.c. Red. Deb. ...	95—100	...	...
450,000	,,	,,	5	5	Do. 5 p.c. Red. Deb. ...	102—107	...	...
450,000	,,	,,	3½	3½	Do. 3½ p.c. Red. Deb. ...	95—100	...	...
100,000	10	22 May '33	6	4	Cape Town, Ltd.	1⅝—2½	...	...
100,000	10	6 Nov.'33	4½	4½	Do. 4½ p.c. Pref. ...	1⅛—3½	...	...
150,000	Stk.	June 21	4½	4½	Do. 4½ p.c. Deb. ...	79—84	...	...
626,860	,,	July 19	6	6	Cardiff Con. Ord.	125—130	...	...
237,860	,,	June 7	5	5	Do. 5 p.c. Red. Deb.	107—112	...	...
98,936	1	Oct. 4	2/-	2/-	Colombo Ord.	1⅝—1⅞*	...	...
24,510	1	,,	1/4½	1/4½	Do. 7 p.c. Pref. ...	23/6—25/6	...	...
739,453	1	Oct. 4.	-/11·48	-/11·48	Colonial Gas Assn. Ltd. Ord.	17/—19/-	...	17/3—17/6
296,144	1	,,	1/3·30	1/3·30	Do. 8 p.c. Pref.	22/—24/-	...	23/3—23/9
1,775,005	Stk.	Aug. 9	5	5	Commercial Ord.	83—88	...	84—85
620,000	,,	June 7	3	3	Do. 3 p.c. Deb. ...	74—79	...	...
286,344	,,	Aug. 23	5	5	Do. 5 p.c. Deb. ...	113—118	...	114½
807,560	,,	Aug. 9	7	7	Croydon sliding scale ...	140—145	...	142½—143½
644,590	,,	,,	5	5	Do. max. div.	108—113	...	111—111½
620,385	,,	June 21	5	5	Do. 5 p.c. Deb.... ...	113—118	...	116½—117½
239,000	,,	Aug. 9	5	5	East Hull Ord. 5 p.c....	98—103	...	...
185,355	,,	Aug. 9	6	6	East Surrey Ord. 5 p.c. ...	120—125	...	...
176,211	,,	June 7	5	5	Do. 5 p.c. Deb. ...	113—118	...	...
250,000	1	July 5	4	7	Gas Consolidation Ord. ...	20/—22/-	...	...
250,000	1	May 24	4	4	Do. 4 p.c. Red Cum. Pref.	19/—21/-	...	19/7½
19,255,284	Stk.	Aug. 9	5⅜	5⅜	Gas Light & Coke 4 p.c. Ord.	24/3—25/3a	+/3	24/3½—25/-
2,600,000	,,	,,	3½	3½	Do. 3½ p.c. max.	82—85	...	83½—84½
4,477,106	,,	,,	4	4	Do. 4 p.c. Con. Pref. ...	99—102	...	100½—101½
2,993,000	,,	July 5	...	3½	Do 3½ p.c. Red. Pref.	101—103	...	102—102½
8,602,497	,,	May 24	3	3	Do. 3 p.c. Con. Deb. ...	78—81	+1	78½—80
3,642,770	,,	,,	5	5	Do. 5 p.c. Red. Deb. ...	112—115	...	114
3,500,000	,,	,,	4½	4½	Do. 4½ p.c. Red. Deb....	111—114	...	112½
700,000	,,	Sept. 6	3½	3½	Do. 3½ p.c. Red. Deb....	94—99	...	98½
270,466	,,	Aug. 23	6	6	Harrogate New Cons. ...	115—120	...	...
213,200	,,	Aug. 9	6	6	Hornsey Con. 3½ p.c. ...	118—123	...	...
5,600,000	,,	Nov. 1	12	8	Imperial Continental Cap. ...	135—140*	...	136½—143½
223,130	,,	July 19	3½	3½	Do. 3½ p.c. Red. Deb. ...	89—94	...	...
285,242	,,	Aug. 9	8½	8½	Lea Bridge 5 p.c. Ord. ...	170—175	...	...
75,000	,,	May 24	†10	†10	Malta & Mediterranean ...	150—160	...	...
392,000	—	Oct. 1	5½	5½	Metropolitan (of Melbourne) 5½ p.c. Red. Deb.	100—103	...	102—103½
231,978	Stk.	Aug. 23	5	5	M.S. Utility 'C' Cons. ...	101—106	...	...
968,657	,,	,,	4	4	Do. 4 p.c. Cons. Pref.	96—101	...	...
360,075	,,	June 21	4	4	Do. 4 p.c. Deb. ...	97—102	...	...
148,955	,,	,,	5		Do. 5 p.c. Deb. ...	115—120	...	...
125,000	—	July 1	3½	3½	Do. 3½ p.c. Rd.Rg.Bds.	96—99	...	...
675,000	Stk.	May 3	†6	†9	Montevideo, Ltd.	91—96	...	...
250,000	,,	Aug. 9	7½	7½	North Middlesex 6 p.c. Con.	150—160	...	...
396,160	,,	Aug. 9	5	5	Northampton 5 p.c. max. ...	110—115	...	...
300,000	,,	Oct. 18	†7	†9	Oriental, Ltd....	155—160*	...	...
468,537	,,	June 7	8	8	Plymouth & Stonehouse 5 p.c.	157—162	...	...
621,667	,,	Aug. 9	8½	8½	Portsmouth & Gosport Cons.	164—169	...	...
241,446	,,	,,	5	5	Do. 5 p.c. max. ...	104—109	...	...
73,350	,,	,,	5	5	Do. 5 p.c. Pref. ...	110—115	...	...
441,275	1	Sept. 20	1/1⅞	1/1⅞	Severn Val. Gas Cor. Ld. Ord.	21/6—23/6	...	21/6
460,810	1	,,	-/10⅛	-/10⅛	,, ,, 4½ p.c. Cum. Pref.	19/6—21/6	...	19/6—20/6
133,201	Stk.	Aug. 23	5	8½	Shrewsbury 5 p.c. Ord. ...	130—135	...	...
1,371,752	1	Sept. 6	1/2⅛	1/2⅛	South East'n Gas. Cn.Ld. Ord.	23/—25/-	...	23/6—24/-
871,636	1	,,	-/10⅛	-/10⅛	Do. 4½ p.c. Red. Cum. Pref.	20/—22/-	...	20/6
498,818	1	,,	4	4	Do. 4 p.c. Cum. Pref. ...	18/—20/-	...	19/3
450,000	Stk.	Aug. 9	4	4	Do. 4 p.c. Deb.	99—102	...	...
150,000	,,	,,	3½	3½	Do. 3½ p.c. Red. Deb. ...	96—99	...	...
6,709,895	,,	Aug. 9	6	5	South Met. Ord.	100—103	...	101—102‖
1,135,812	,,	,,	6	6	Do. 6 p.c. Irred. Pf. ...	131—136	...	...
850,000	,,	,,	4	4	Do. 4 p.c. Irred. Pf. ...	98—101	...	99½
1,895,445	,,	June 21	3	3	Do. 3 p.c. Deb. ...	75—80	...	77⅝—79
1,000,000	,,	July 5	5	5	Do. 5 p.c. Red. Deb....	110—113	...	110
1,543,795	,,	Aug. 9	6	6	South Suburban Ord. 5 p.c....	120—125	...	122½
512,825	,,	,,	5	5	Do. 5 p.c. Pref....	110—115	...	112—112½
500,000	,,	,,	4	4	Do. 4 p.c. Pref....	95—100	...	...
250,000	,,	,,	...	§18/9	Do. 3½ p.c. Red. Pref.	98—101	...	...
888,587	,,	June 7	5	5	Do. 5 p.c. Deb....	115—120	...	117—118
250,000	,,	,,	4	4	Do. 4 p.c. Deb....	98—101	...	...
200,000	,,	Sept. 20	...	3½	Do. 3½ p.c. Red. Deb.	94—99	...	...
427,859	1	Nov. 1	1/2⅛	9⅜	S. Western Gas & Water Ord.	18/6—20/6*	—/6	19/6
160,523	1	,,	-/10⅛	-/10⅛	Do. 4½ p.c. Red. Cum. Pf.	19/6—21/6*	—/6	...
110,000	Stk.	June 21	4	4	Do. 4 p.c. Red. Deb. ...	97—102	...	...
750,541	,,	Aug. 9	5⅜	5	Southampton Ord. 5 p.c. ...	111—116	...	...
148,836	,,	June 7	4	4	Do. 4 p.c. Deb.	97—102	...	100—100½
350,000	,,	Aug. 23	5½	5½	Swansea 5½ p.c. Red. Pref. ...	110—115	...	111½
94,000	,,	June 7	3½	3½	Do. 3½ p.c. Red. Deb. ...	95—100	...	...
1,076,490	,,	Aug. 9	6½	6½	Tottenham and District Ord.	133—138	...	133—134½
409,835	,,	,,	5½	5½	Do. 5½ p.c. Pref....	121—126	...	...
62,235	,,	,,	5	5	Do. 5 p.c. Pref. ...	110—115	...	...
371,850	,,	June 7	4	4	Do. 4 p.c. Deb. ...	97—102	...	...
888,629	1	Oct. 4	6	4	U. Kingdom Gas Cor. Ord.	20/—22/-	...	20/—20/7½
968,841	1	May 3	4½	4½	Do. 4½ p.c. 1st Cum. Pref.	20/—22/-	...	21/—21/4½
745,263	1	June 7	4½	4½	Do. 4½ p.c.2nd Non-Cum.Pf	17/—19/-	...	17/9
1,000,000	Stk.	Sept. 20	3½	3½	Do. 3½ p.c. Red. Deb. ...	96—99	...	97½
373,939	,,	Aug. 9	7	7	Uxbridge, &c., 5 p.c. ...	138—143	...	...
133,010	,,	,,	5	5	Do. 5 p.c. Pref. ...	109—114	...	...
1,371,138	,,	Aug. 9	7	7	Wandsworth Consolidated ...	140—145	...	142—143
1,620,615	,,	,,	5	5	Do. 5 p.c. Pref ...	117—122	...	...
500,000	,,	,,	4	4	Do. 4 p.c. Pref. ...	98—101	+1	99—100½
1,343,964	,,	June 7	5	5	Do. 5 p.c. Deb. ...	115—120	...	...
383,745	,,	,,	4	4	Do. 4 p.c. Deb. ...	97—102	...	...
558,342	,,	Aug 9	7	7	Watford and St. Albans Ord.	138—143	...	...
200,000	,,	,,	5	5	Do. 5 p.c. Pref. ...	109—114	...	...
200,000	,,	,,	5½	5½	Do. 5½ p.c. Pref. ...	121—126	...	...
200,000	,,	June 7	4	4	Do. 4 p.c. Red. Deb.	97—102	...	...
100,000	,,	,,	3½	3½	Do. 3½ p.c. Red.Deb.	95—100	...	...

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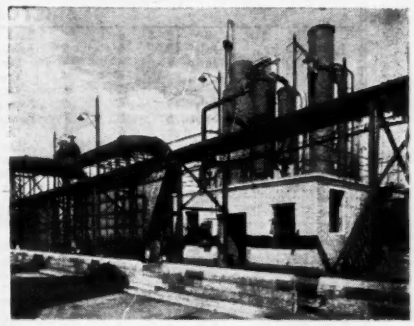

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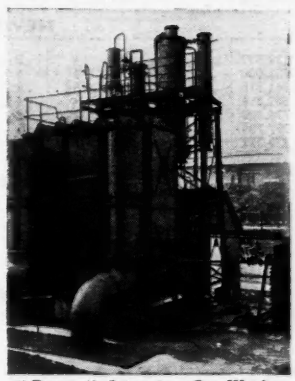

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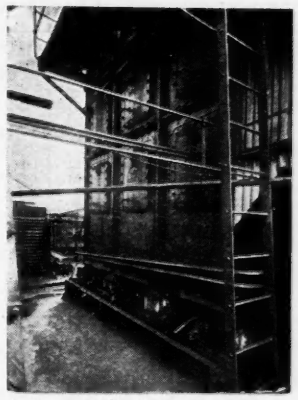

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Issue. £	Stock or Share	When ex-Dividend.	Dividends. Prev. Hf. Yr. % p.a.	Dividends. Last Hf. Yr. % p.a.	NAME.	Quotations. Nov. 5.	Rise or Fall on Week.	Transactions Lowest and Highest During the Week.
BRISTOL EXCHANGE.								
347,756	Stk.	July 19	6	5	Bath Cons.	120—122	...	...
1,667,250	,,	July 19	5	5	Bristol, 5 p.c. max.	117—118	...	...
120,420	,,	June 7	4	4	Do. 1st 4 p.c. Deb. ...	100½—102½	...	...
217,870	,,	,,	4	4	Do. 2nd 4 p.c. Deb. ...	100½—102½	...	...
328,790	,,	,,	5	5	Do. 5 p.c. Deb.	120—123	...	...
274,000	,,	July 19	5	5	Newport (Mon.) 5 p.c.max. ...	101—106	...	...
13,200	12	Sept. 6	8	7	Pontyp'l Gas & W. 10 p.c. 'A'	13—14	...	...
13,600	10	,,	6	5	Do. 7 p.c. 'B'	11½—12½	...	...
40,000	10	,,	6	5	Do. 7 p.c. 'C'	11½—12½	...	...
140,778	Stk.	Aug. 9	5	5	Weston-super-Mare Cons. ...	110—112	...	...
64,338	,,	June 21	4	4	Do. 4 p.c. Deb.	96—98	...	...
33,340	,,	,,	7½	7½	Do. 7½ p.c. Deb.	157—160	...	...
LIVERPOOL EXCHANGE.								
157,150	Stk.	Aug. 9	6½	5	Chester 5 p.c. Ord.	104—109	...	...
92,500	,,	June 21	4	4	Do. 4 p.c. Pref.	97—101	...	...
36,430	,,	,,	3½	3½	Do. 3½ p.c. Deb....	89—92	...	...
41,890	,,	,,	4	4	Do. 4 p.c. Red. Deb. ...	98—102	...	...
2,167,410	,,	Aug. 23	6	6	Liverpool 5 p.c. Ord. ...	125—127	...	...
245,500	,,	June 21	5	5	Do. 5 p.c. Red. Pref. ...	99—104	...	...
306,083	,,	July 1	4	4	Do. 4 p.c. Deb. ...	102—104	...	...
106,280	,,	Aug. 9	10	10	Preston 'A' 10 p.c.	206—216	...	...
188,219	,,	,,	7	7	Do. 'B' 7 p.c.	147—157	...	...
NEWCASTLE EXCHANGE.								
122,577	Stk.	Aug. 9	8	8	Blyth 5 p.c. Ord.	165—166	...	...
732,000	,,	Aug. 9	5	5	Hartlepool G. & W. Cn. & New	117—119	...	...
2,061,315	,,	Aug. 9	5½	5	Newcastle & Gateshead Con.	23/3—23/9a	...	...
682,856	,,	,,	4	4	Do. 4 p.c. Pref. ...	97—99	−1½	...
776,706	,,	June 21	3½	3½	Do. 3½ p.c. Deb. ...	90½—91½	...	...
277,285	,	Nov. 1	5	5	Do. 5 p.c. Deb. '43...	105—107	...	...
332,351	,	Aug. 23	6	6	Sunderland 6 p.c. max. ...	139—141	...	...
NOTTINGHAM EXCHANGE.								
542,270	Stk.	Aug. 9	9	6	Derby Con.	140—150	...	...
55,000	,,	June 7	4	4	Do. 4 p.c. Deb.	100—105	...	...
20,000	10	June 7	5	5	Long Eaton 5 p.c. Pref. ...	10—12	...	...
80,000	Stk.	,,	5	5	Do. 5 p.c. Deb. ...	105—110	...	...
SHEFFIELD EXCHANGE.								
10,000	Stk.	Sept. 20	10	10	Great Grimsby 'A' Ord. ...	210—220	...	...
6,500	,,	,,	10	10	Do. 'B' Ord. ...	210—220	...	...
79,000	,,	,,	10	10	Do. 'C' Ord. ...	205—210	...	...
1,806,339	,,	Aug. 23	6	6½	Sheffield Cons.	144—148	...	...
95,000	,,	July 5	4	4	Do. 4 p.c. Deb.	100—103	...	...
Supplementary List of Stocks and Shares not Officially Quoted								
202,152	Stk.	Sept. 6	25/-b	5	Ascot Ord.	100—105	...	...
128,182	,,	July 5	5	5	Do. 5 p.c. Pref.	108—113	...	...
573,156	1	May 24	5	5	Assd. Gas and Water Ord. ...	19/6—21/6	...	...
167,506	1	...	...	...	Do. 4 p.c. Red. Cum. Pref.	19/—20/-	...	20/—20/1½
253,118	1	...	...	...	Do. 4 p.c. Irred Pref. ...	18/—20/-	...	...
500,000	1	May 24	4½	4½	Do. 4½ p.c. Red. Cum. Pref.	19/6—21/6	...	...
500,000	Stk.	Sept. 6	3½	3½	Do. 3½ p.c. Red. Deb. ...	95—100	...	96½—96½
31,035	1	Aug. 23	...	/4½	Associated Utilities 4 p.c. Pref.	16/6—18/6	...	...
100,000	Stk.	...	...	...	Do. 3½ p.c. Red. Deb.	95—100	...	...
17,000	,,	Aug. 23	8	8	Bognor Orig. Ord. 'A' ...	160—170	...	...
62,210	,,	,,	8	8	Do. New Addl. 'A' ...	160—170	...	...
87,160	,,	,,	7	7	Do. New 7 p.c. max. ...	141—146	...	...
37,440	,,	Aug. 9	10	10	Cam. Univ. & Town 10 p.c.max.	193—203	...	...
125,970	,,	,,	7	7	Do. 7 p.c. max.	135—140	...	...
39,025	,,	,,	5	5	Do. 5 p.c. max.	98—103	...	...
65,000	,,	Aug. 9	8½	7½	Eastbourne 'A' 5 p.c. ...	158—163	...	159
198,000	,,	,,	7	6	Do. 'B' 3½ p.c.	128—133	...	130
112,312	,,	,,	5	5	Do. 5 p.c. Pref.	108—113	...	...
130,000	,,	June 21	5	5	Do. 5 p.c. Deb.	115—120	...	...
24,000	30	Aug. 23	8½	8½	Great Yarmouth 8½ p.c. max.	44—49	...	...
59,400	30	,,	7½	7½	Do. 7½ p.c. max.	44—49	...	...
51,160	Stk.	June 7	5½	5½	Do. 5½ p.c. Deb.	120—125	...	...
152,600	,,	Sept. 6	9	8	Guildford Cons.	170—175	...	...
54,055	,,	,,	5	5	Do. 5 p.c. Pref.	110—115	...	102½
68,250	,,	June 7	5	5	Do. 5 p.c. Deb.	113—118	...	...
156,600	,,	Aug. 23	7½	7½	Hampton Court Cons. ...	158—163	...	...
73,620	,,	Sept. 6	8½	8½	Luton Cons. 'A'	163—168	...	...
107,960	10	Sept. 20	5½	4	Mid Kent Ord.	8¾—9¾	...	...
230,940	Stk.	Aug. 9	10	10	Oxford & District Ord. ...	205—210	...	...
47,112	,,	,,	5	5	Do. 5 p.c. Pref.	108—113	...	...
50,000	,,	,,	6	6	Do. 6 p.c. Red. Pref. ...	110—115	...	...
126,193	,,	May 3	7½	7½	Peterborough Ord.	159—169	...	...
64,990	,,	Sept. 6	7½	6½	Redditch Ord.	125—135	...	...
166,850	,,	Aug. 9	8	8	Romford Ord.	155—165	...	...
60,000	,,	,,	4	4	Do. 4 p.c. Pref.	97—100	...	...
44,000	,,	Sept. 20	5	5	Do. 5 p.c. Deb.	113—118	...	...
25,570	,,	Aug. 9	5½	5½	Rugby 5½ p.c. Pref.	125—130	...	...
25,000	,,	,,	6	6	Do. 6 p.c. Red. Pref. ...	106—111	...	...
42,750	,,	June 7	5½	5½	Do. 5½ p.c. Deb.	122—127	...	...
10,950	,,	Aug. 23	8	8	Ryde Ord.	158—163	...	...
27,825	,,	Aug. 23	8	8	Shanklin & Ventnor Cons. ...	158—168	...	...
270,086	,,	Sept. 6	7	7	Slough Ord.	135—140	...	...
21,000	,,	June 21	5	5	Do. 5 p.c. Deb.... ...	112—117	...	...
28,872	1	Nov. 1	5½	5½	S. Midland Gas Cpn. Ltd. Ord.	19/—21/-*	...	...
28,866	1	Sept. 6	4½	4½	Do. 4½ p.c. Red. Cum. Pref.	18/6—20/6	...	...
137,730	Stk.	Aug. 9	7	7	Southgate & Dist. 7 p.c. max.	140—145	...	...
62,500	,,	,,	5	5	Do. 5 p.c. Pref.	110—115	...	...
117,228	,,	Aug. 23	5	5	Swindon Cons.	106—111	...	...
60,425	,,	June 7	5	5	Do. 5 p.c. Deb.	110—115	...	...
64,380	,,	June 7	5	5	Torquay and Paignton 5 p.c. Pf	110—115	...	...
500,000	1	...	...	...	United Kingdom Gas Corpn. 4 p.c. 1st Red. Cum. Pref.	19/—21/-	...	20/4½
130,000	Stk.	Aug. 9	8	5	Wakefield Ord.	120—125	...	...
81,650	,,	,,	5	5	Do. 5 p.c. max.	103—108	...	...
82,000	,,	Aug.	6	6	Weymouth Ord.	103—108	...	...
98,384	,,	Aug. 9	6	6	Wolverhampton 6 p.c. Pref....	120—125	...	...
160,000	,,	June 21	5½	5½	Do. 5½ p.c. Rd. Db	108—113	...	...
90,000	,,	June 21	5	5	York 5 p.c. Red. Deb. ...	105—110	...	...
133,640	,,	July 19	6½	6½	Yorktown (Cam.) 5 p.c Cons.	128—133	...	...
120,000	,,	,,	5	5	Do. 5 p.c. Pref.	108—113	...	...
35,000	,,	June 7	5½	5½	Do. 5½ p.c. Deb.	123—128	...	...

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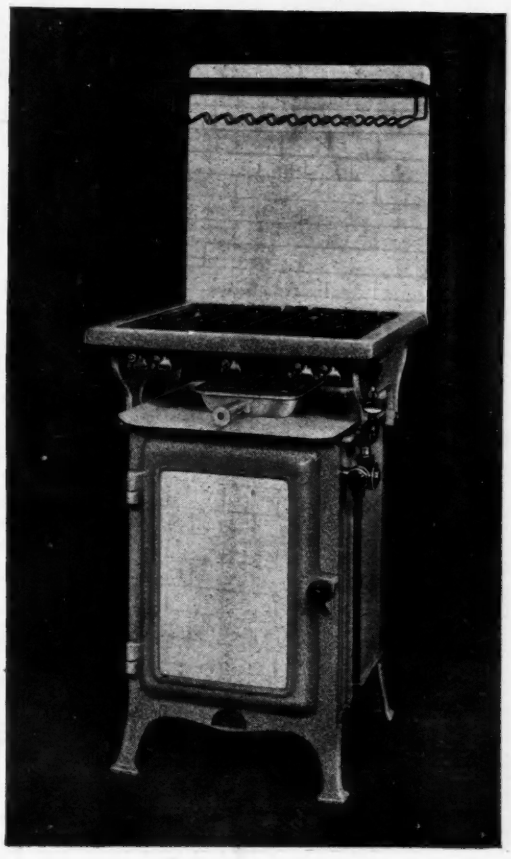

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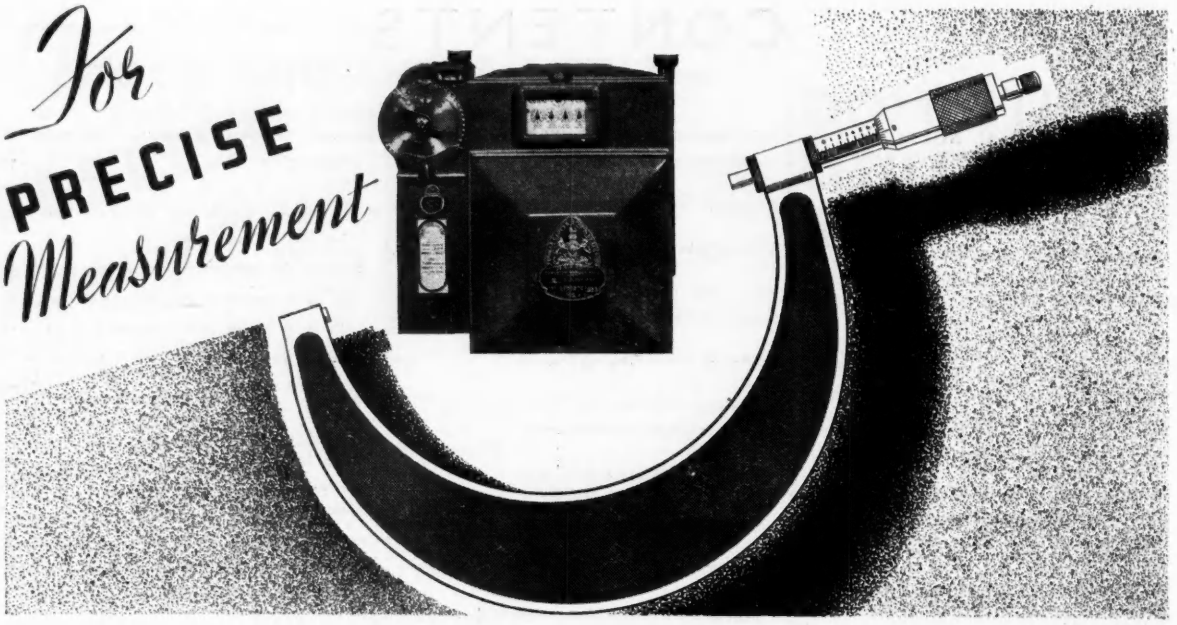

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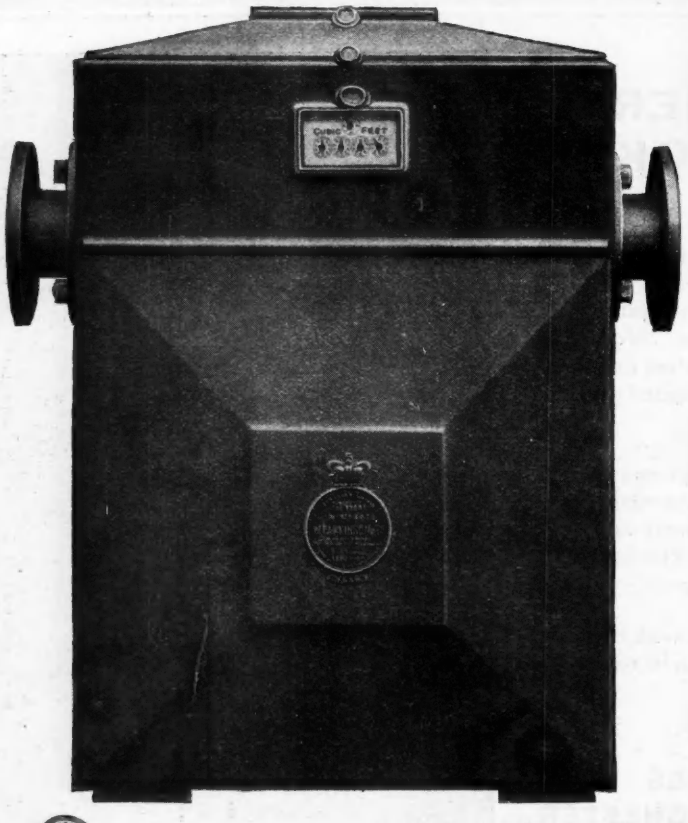

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